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A GLANCE AT AERONAUTICAL SCIENCE.*

By MR. W. CLARE.

From "The Mechanics' Magazine."

The reading of the Aeronautical Society's report for the past year is a task somewhat tinged with a shade of the melancholy when we consider how little has really been done in that time—not one new theory has been advanced, not one experiment of value made. It is at all times pleasant to feel that we are moving forwards in the track of any scientific discovery; indeed, we all of us have a great objection to a retrograde motion, while many dislike progressing (after the manner of a crab) in a sideways fashion, or, in other words, studying the collateral branches of an incomplete science. But when we have come to the end of our tether in a forward direction, stuck in the mud as it were, or have wandered into one of the many and devious paths of error, it becomes us, I think, the rather to retrace our steps, and as we retire carefully to note the ground over which we pass, with a view of discovering where we first turned aside from the right path, and, instead of helplessly sticking in the mud and merely looking about us, to go back and endeavor to find some way of successfully passing over, or going round, the discouraging slough.

Now this is the scheme, the adoption of which I think would be beneficial to the at present infantile science of aeronautics, and my object this evening is to try and gently lead you back to your place of starting and there to leave you, hoping that with the experience already gained you may be more successful in your next journey towards the solution of those mysteries which now so closely enwrap the almost chimeric science of the theory and practice of flight.

The method by means of which I shall hope to attain this object will be to endeavor to point out, as far as I am able, a few of the many paths of error, and to try and explain the nature of that mud in which we seem so firmly embedded. The few sentences I am about to read are, for the most part, founded upon the assumption that the majority of those present this evening have carefully perused the four interesting reports of the proceedings of the Society issued by it.

History furnishes us with many interesting proofs that artificial flight must, in a greater or less degree, have occupied the minds of the learned in every age. The Jews had their cherubim, carried out, moreover, under divine instruction; the Assyrians have left us their winged bulls, the Greeks their sphinxes, while Roman writers tell us how the mythical personage Dædalus flew across the Ægean sea, and this nation has bequeathed to us various reliefs illustrative of what appear

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to be well-proportioned wings, which have possibly played some part in the manufacture of the angel of the painter. The fact that the problem of flight has been present to the minds of so many myriads of the human race displays to us the magnitude of the enterprise upon which we have entered, and teaches us how necessary it is to labor with the strength of unity, and to be careful to extend our researches in a right direction. "Onwards and *upwards*" must be our motto. The ancients seem to have had one idea of flight only, but to us the subject seems naturally to divide itself into two branches, namely, that of aerial ascent, locomotion, and navigation by means of power, and individual manual flight; this latter appears to me the purer branch of the science, one more worthy our consideration, and the one in which nature seems the more inclined to help us. The bird has been greatly upheld as a model teaching us how to fly, though there is no reason why a bird should teach us practically how to fly any more than a fish has taught us how to swim or how to propel our vessels, but they have hitherto materially assisted the pursuit of the theory of flight, and doubtless may yet somewhat help us in our investigations of its practice. Man had to learn to swim, he has yet to learn to fly. Flight is little else than swimming, though in a medium far less dense than that of water, and a corresponding increase in speed, combined with wings sufficiently long to permit us to decrease this speed to a practical limit, seems only required to enable us to float as calmly in the unyielding air as we now do in water.

This remark paves the way to the first error, and a very common one, to which I desire to direct your notice for a few moments, which is, that heavy wings or heavy machinery must necessarily retard or render impossible flight. Now, I imagine that if, when the "Great Eastern" was building, anyone had been absurd enough to say, "This ship is so heavy it can never float," we should have answered, "Nonsense, weight is nothing, it is a question of displacement only." There is little theoretical difference between flight in water and flight in air; the difference is a practical and mechanical one, and provided our wings or machinery displace sufficient air in proportion to their weight we need have no fear of making them too heavy. This proportion, however, varies, nature teaching us that the amount of wing surface in proportion to weight decreases as the weight increases. It is hardly necessary here to remind you that ratios do seem to relatively exist between weight, power, and surface.

The second part of error to which I wish to call your attention is the still too prevalent, though happily almost exploded idea, that air cells help, except in a very limited degree, the flight of birds. Dr. Wenham has, I believe, already attracted your attention to the fallacy of this theory (for it has never gone beyond theory), and allow me to ask, Why air cells should assist a bird to rise in the air? If, as is reasonable to suppose, these cells are fitted with an extremely rare gas, a power of buoyancy would of course be the result; but what a power! under the most favorable circumstances bearing something like the enormous rate of ¼ per cent. (.025) to the weight. Were, however, a bird thus buoyed up, as many still suppose, flight would be rendered impossible by that very buoyancy, as impossible as the flight of a balloon—by flight I mean of course controllable flight. This air cell business is by far the weakest argument yet brought forward.

Another common error seems to be the notion that models are such a necessary and essential help to the object of this Society. The province of a model is to explain an invention to others after it has been made, and not to assist the inventor. In every great invention they have (except within very restricted limits) been found to be almost useless, and most of our valuable discoveries have been made and carried out without their aid. Watt's first condensing engine had a cylinder of 18 in. diameter, which is, I believe, somewhat above the average size of the cylinders now in general use, and I imagine that if would-be inventors of artificial flight would, like Watt, first mature their theories with no aid from models, save those of a most elementary description, there would be but little difficulty, except with regard to practical details, in afterwards carrying out those theories. The model is a rock upon which many an inventor has been broken up; if a project succeeds in the form of a model it often fails in after practice, and *vice versâ*. The

impenetrable stupidity of model makers frequently renders models worse than useless, proved by the fact that inventors rarely employ the same modellist twice.

Another devious path is the almost general hankering after steam in some form or other, which has existence in the minds of aeronautical people. I fear the steam-engine is far too wasteful a machine ever to suit the requirements of aerial navigation, and when we consider that in a good condensing double cylinder expansive steam-engine we waste (I speak from memory only) about 90 per cent. of coal, and that a bird uses his power with, I suppose, no appreciable waste, the comparison becomes very unsatisfactory and a very unpleasing one to dwell upon. Nature, however, teaches us that the power necessary for the flight of a bird is after all but small (the horse power of a pelican being generously estimated at 1-11th by Mr. Wenham, I believe), but it is used in a manner far more economical than machinery is ever likely to effect. Birds feel the air and seem toguide their flight by nervous sensation; machinery, I fear will never accomplish this, though man undoubtedly will. Dr. Smyth, in his experiments with the wings of a pigeon dried in an extended position, found that, however cleverly and closely he imitated the motions of a pigeon by means of a spring, he could raise no weight except very occasionally, and then by jerks; which proves that great power is not required so much as a successful manipulation of a small power.

Will it be considered superfluous here to remind you that, though birds of the struthious or ostrich order do not fly, weight is by no means the cause of their failure? You will perhaps allow me to quote in a parenthesis the quaint old naturalist Buffon's contrary opinion on this subject. He says: "The ostrich is generally considered as the largest of birds, but its size serves to deprive it of the principal excellence of this class of animal—the power of flying. The medium weight of this bird may be estimated at 75 or 80 lbs., a weight which would require an immense power of wing to elevate into the atmosphere, and hence all those of the feathered kind which approach to the size of the ostrich, such as the cassowary, the dodo, neither possess nor can possess the faculty of flight." The drift of all this preamble and quotation is that I wish to ask you why and how it is that these birds are not constructed for flight. There doubtless is some wise reason, but I have never yet heard an explanation which has in any way satisfied me.

Another query it would be well to have definitely answered is this: We frequently see birds, especially swallows, flying at an angle at times as great as 45 deg. to the horizon. By what means do they attain this position, how maintain it, and how return from it to the horizontal? It will be useful to know, because when man flies, as he undoubtedly soon will do, he will require similar steering, balancing, or tail apparatus. We must endeavor also in our investigations to forget the very existence of such a thing as a balloon, which is at best but a meteorological instrument, though a most useful, and, when in the skilful hands of Mr. Glaisher or some few others, a very scientific one. It is altogether foreign to the ultimate aim of this Society. We must study and put into practice nature, and, to a certain extent, leave art and chemistry alone. One more suggestion here too. As we can only hope to build up future successes on past failures, I think all failures ought to be discussed and analyzed; for instance (though the remark applies to others), Mr. Spencer was going to fly at the Crystal Palace in 1868; may I ask, with every apology for my abruptness, why he did not?

Now let us consider the nature of the mud in which I have said we are stuck. The cause of our stand-still, briefly stated, seems to be this: men do not consider the subject of "aerostation" or "aviation" to be a real science, but bring forward wild, impracticable, unmechanical, and unmathematical schemes, wasting the time of the Society, and causing us to be looked upon as a laughing stock by an incredulous and sceptical public.

To explain what I mean I need only refer you to the last meeting, July 14, 1869, when, after a very learned dissertation on the breaking strain of brass, a gentleman (Mr. R. Sheward), though I do not wish it to be understood that I am making an exclusive raid upon this gentleman, explained to us a machine caused to rise by the principle of exhaustion, and showed us the small steam-engine and exhauster neatly stowed away in a kind of small boat. Now had this gentleman calculated (or got some one else to do it for

him) the power required to diminish the air above his machine sufficiently to allow of only a very moderate speed, he would for obvious reasons have found it enormous; indeed, I doubt if his engine would even find standing room on his aeroplane. I have made a rough calculation of the probable power required (the plane being 60 ft. by 40 ft.), and find it would be at a very moderate computation from 200 to 300-horse power.

Now, we ought and must try to avoid these flights of fancy (which seem to be the only methods of flying understood by many) and deal with the solid and tangible facts at our disposal, which facts can be greatly amplified by more careful, mathematical, scientific, and practical investigation and research than has hitherto been made into the method of flight adopted by birds, the bat, and insects, the power they respectively employ, and the sustaining surface they severally have in proportion to their weight, together with, if possible, their speeds. We shall then, knowing more thoroughly the conditions and requisites of flight, be in a position the better to contend with those difficulties which have hitherto been our conquerors. But while pursuing what I have, perhaps, erroneously called the theory of flight, let us not forget that artificial flight is more a practical question than a theoretical one, and as such must be practically and experimentally studied by practical and experimental men.

The questions I asked of you, and the inquiries I made a sentence or two back, will, I think, bear far more study than has at present been bestowed upon them, though I am aware that they have been to a limited extent answered before, M. de Lucy having been the chief contributor. The facts deducible from these somewhat crude answers amount to this, that we have no doubt whatever that man can be made a flying animal, no doubt that he will eventually perch on Stafford House, but that there are some rather awkward, though only practical difficulties in the manufacture of the requisite apparatus. Few will, I think, in the present day (no one here I hope) venture to dispute that man, the lord of creation, is capable of flying; such doubt would be little short of a reproach on his Maker; he can walk upstairs, though in so doing he uses his power in a most wasteful and unmechanical way, and surely he can mount upon air, which, properly manipulated, is as solid as any stair; he must, however, first remove another great stumbling-block.

Man has at present, owing to his ignorance and clumsiness, no means of safely getting up the initial velocity necessary to render the air a solid support (I am here supposing that he has surmounted the slight difficulty I spoke of relative to making his wings). To obtain this velocity he can of course insure his life and start from some eminence; but this is considered by many to be an "eminently" dangerous experiment. Perhaps it is; I think it so myself, and I will, therefore, with your kind permission, before I conclude, briefly lay before you an undeveloped idea of mine, having in view the reduction of this danger, which, though rough, is one which perhaps may assist, in however limited a degree, the object for which we have met.

A word here in passing. No one has yet succeeded in flying any distance, and for this sole and simple reason, no one has yet constructed the necessary apparatus practically in accordance with the theories already advanced in the science. This is a broad statement to make, and one which will doubtless encounter a good deal of disapprobation and dissent; but I honestly believe it to be the truth, and my aim now is to endeavor to point out a safe and simple means of practically experimenting on the requisites of flight. In Germany they teach swimming by suspending the learner from a rope; in England we must teach flying in the same manner, and I propose turning our aspiring (soon perhaps perspiring) experimenter into a rotatory pendulum, like the governor ball of a steam-engine. To make myself more intelligible, I will now proceed to explain my proposal. The rod of my rotatory pendulum is a rope, as long as can conveniently be obtained, a captive balloon even being used as the centre if requisite, and the bob or governor ball is represented by the experimenter and his apparatus. In accordance with the idea expressed in an early part of this paper, I would at once fit out my man with the theoretical length of wing (open to discussion perhaps). Not minding the necessary weight, which should, however, be as little as possible,

a man, like a bird, should be able to spread his wings, as the experimenter will lift himself on his wings and not drag them after him. The wing is not a lever, or if it is, is one of a very doubtful order, having a fulcrum for the whole of its length. He should, for various reasons, work them mainly with his legs, leaving his arms and hands free for guidance and balancing. They would be somewhat similar in construction to those described by Mr. Wenham in his exceedingly clever and able paper read at the first meeting of the Society, in 1866, which he then repudiated as utterly impracticable. The reason I propose at once trying what seems to be a proper length of wing is, that although I agree with Mr. Wenham that the slip of the screw renders it an undesirable sustaining power, I still think that superposed planes are in a measure liable to the same objection at low speeds as the screw, viz., that they, though probably in a much less degree, use the same air more than once.

These wings, which of course girder-like and bird-like would, if supported at the tips, be capable of sustaining the weight of the operator in the middle, would at their extremities be fitted with grooved wheels, which wheels by means of vanes on them would detach themselves from the apparatus immediately on the experimenter cutting a line which hitherto had restrained them. An inclined plane, composed of two stretched ropes and placed tangentially to an average circle described by the pendulum, would serve to give the concern the requisite initial velocity, the wings being supported on the grooved wheels before spoken of. When the man came to the end of this plane the pendulum line would come into action, and, in the event of his coming to grief, would catch him ; but if it proved successful he could soar round and round without the slightest fear of danger. This experiment, and of course it would be nothing but an experiment, could be carried out without the aid of the inclined plane, but I am inclined to think it would be more satisfactory with it. I cannot forbear conjecturing that if such an experiment as this did prove a failure (as it doubtless would the first time of trial) we should still have learnt far more from it in a day than we could by talking here for a month. I have neither the time, place, inclination, nor means to carry out such an undertaking as this entirely on my own account, but I should be glad to co-operate with the council of this society in trying some such experiment or any modification of it, and would cheerfully offer my services and lend myself as the pendulum bob or chief victim.

Another experiment, which seems to me well worthy of trial and investigation, is one with which you are all familiar, proposed by Mr. St. Martin and afterwards with modifications by Mr. Stewart Harrison, which I will call the "velocipede aerostatic apparatus." The speed of the velocipede is, however, but small when regarded as the initial speed of flight, and with a view of increasing this speed I venture to suggest an amendment.

Some years ago—before the velocipede mania had existence—I tried many experiments with what I may term a species of wheel skates, the wheels being of considerable diameter and having their centre somewhere about the region of the knee. The speed I managed without any fatigue to attain was something tremendous and almost incredible, but the bruises and falls I managed to sustain were equally tremendous and almost incredible, and bodily fear at length led me to discontinue the trials. It occurred to me last week that this apparatus, in conjunction with wings, might prove tolerably safe, while it would supply the speed asked for by so many. To such, or any interested in this kind of research into flight, I shall be happy to afford any further information they may require.

Let us do something, take some active steps, and not let another year roll by spent in dreamy speculation and unprofitable theorizing. The prayer of Ajax should be ours—light, more light. Experiment would clear away many imaginary obstacles. In nearly every great discovery difficulties have been thought to exist which practice has dissolved as the sun a morning mist. Locomotives were constructed with clog wheels to gear into racks till practice proved that smooth tyres and rails met all requirements, and then how easy all calculations on adhesive force and friction became. It will, I trust, be found to be so with flight ; the dust of power and weight is at the present moment thrown in our eyes, which I believe the water-cart of practice would

easily lay. Let us in our experiments bear in mind Solomon's description of the inventor, "I Wisdom dwell with Prudence and find out knowledge of witty inventions." May these twin attributes of the successful discoverer, Wisdom and Prudence, ever pervade our meetings here, and take up their abode with our individual researches at home.

I do not invite or even wish for discussion on this paper, it is simply unworthy of it, as I have merely tried to show you how little we know on the subject of flight, being well assured that the first and most important step towards knowledge is a thorough conviction of ignorance. In conclusion, you will allow me to assure you all that I shall be well satisfied if the display of my ignorance will lead and encourage you to exhibit your knowledge and help to provoke inquiry into and to develop, in however small a degree, the theory, and more particularly the practice, of so important but hitherto so unattainable a subject as the science of flight—not the science of artificial flight only, but the science of natural although manual flight.

ON THE MOTION OF WATER IN RIVERS AND CANALS.

By ALBERT HILL, C. E.

I. *Average Velocities.*

Water moves either in natural or artificial channels. In the first case it forms rivers, brooks, etc.; in the second, canals, ditches, etc.

The bottom and side-slopes of the channel constitute what is termed the *bed*. A plane which is vertical to the direction of the current gives by its intersection with the bed, the *cross-section*, the area of which we shall designate in these pages by *a*. That part of the cross-section which is in contact with the water is called the *water-perimeter*, and will be designated by *p*. Any vertical plane in the direction of the current gives the *profile* of the bed.

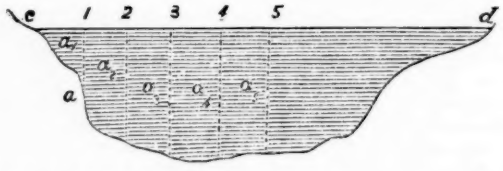
The cause of the motion of water in its bed is simply gravity, inasmuch as the bottom is an inclined plane. By *fall* we understand the perpendicular distance of any two points of the profile.

Between the fall h, the distance l, to which this fall corresponds, and the angle S which the bottom or the surface forms with a horizontal line, there exists the relation

$$\sin \delta = \frac{h}{l}$$

The velocity of the current is different in different points of the same cross-section; it is greatest in the point farthest from both bottom and side-slopes, and decreases with the distance from these.

By average or *mean-velocity* is meant



that uniform velocity which the current is supposed to have in every part of the cross-section in order to discharge the same quantity of water as is actually discharged with different velocities.

Let Q be the quantity of water discharged in one second through a certain cross-section, c the average velocity of the current, then we have the equation

$$Q = a\,c$$

In order to ascertain the average velocity of a cross-section, the following method is resorted to:

On the line $c\,d$ of the surface several points, 1, 2, 3, 4, are taken at a certain distance from one another.

From these points perpendicular lines are supposed to be drawn to the bottom, and then the areas a_1, a_2, a_3, a_4, a_5, of these parts of the cross-section, thus formed, calculated.

Three different velocities v_1, v_2, v_3 (at the top, middle, and bottom), in the same perpendicular are then ascertained, added together, and their sum divided by the number of observations, for the average velocity of that perpendicular, *e. g.*, the average velocity of the perpendicular 1 *a* would be

$$\frac{v_1+v_2+v_3}{3}$$

of 2 $$\frac{v_1'+v_2'+v_3'}{3} \text{ etc.}$$

Each of these average velocities is now multiplied by the corresponding part of the cross-section, thus

$$a\left(\frac{v_1+v_2+v_3}{3}\right),\ a_2\left(\frac{v_1'+v_2'+v_3'}{3}\right) \text{ etc.}$$

These products all added and their sum divided by the entire cross-section will give the average velocity of this latter.

Various instruments have been constructed by which to ascertain the velocity of currents. The simplest of these are the so-called "*swimmers*," hollow spheres of tin, partly filled with shot to secure their immersion, and varnished with some bright color to render their motion more easily observable. The velocity of the current is found by dividing the distance l by the time t which it takes the swimmer to pass over this distance; hence

$$v_1 = \frac{l}{t}.$$

To ascertain the velocity in different depths, two swimmers are connected by a wire, one of which is so ballasted as to sink completely, the other sufficiently to permit its being perceived just above the surface.

Let c represent the velocity of the upper swimmer alone, v the velocity of the two combined, then will x, the velocity of the lower swimmer be found from the equation

$$x = \frac{c + v}{2}$$

The *river-quadrant* which is employed to find the velocity of a current on the surface of the water consists of a graduated quadrant and a ball suspended in the centre by a thread. The specific gravity of the ball must be greater than that of water.

The velocity is calculated from the angle which the thread makes with the perpendicular arm; for from the weight Q of the ball under water, and the thrust $P = a\,v^2$ (since this latter increases uniformly with the square of the velocity and the area of the section of the ball), is obtained a resultant force, the direction of which is imparted to the thread, and the relation of its angle with the perpendicular is expressed by

$$\text{tang. } \alpha \frac{\mu\, a\, v^2}{Q} \text{ whence}$$

$$v = \sqrt{\frac{Q}{\mu\, a}} \cdot \sqrt{\text{tang } \alpha}$$

in which μ is a co-efficient found by experiments.

$$\text{Making } m = \sqrt{\frac{Q}{\mu\, a}} \text{ we have}$$

$$v = m\sqrt{\text{tang. } \alpha}$$

in which m is again a coefficient found by experiments. This coefficient is constant for the same ball, and is best found by immersing the ball in water, the velocity of which is already known. Dividing v then by tang. α gives the constant m for all other experiments with the same instrument.

The numerous experiments made by different engineers have not as yet resulted in the establishment of a general law for the different velocities in the different points of a cross-section. Egtelwein and others believe themselves to be correct in asserting that the velocity in the same vertical decreases from the surface with the depth in an arithmetical progression.

Let V be the velocity, m the depth of the river in metres, v the velocity in a certain point, then would

$$v = V\,(1 - .025\,m).$$

a result which the experiments of others do not verify.

Let C represent the maximum of velocity in the channel, c the average velocity of a cross-section, then we have nearly correct:

$$c = 0.84\ C$$

for C within the limits .2 and 1.5 metres.

For other values of C Prony proposes the formula:

$$c = \frac{C\,(2.372 + C}{3.153 + C}$$

Baumgartner does not think this formula quite reliable for greater velocities on the surface, and advises the multiplication of the second member of that equation by 0.8.

II. *Uniform motion of water in canals.*

If the average velocity c remains the same for a greater distance l, and if therefore for this latter, the cross-section a remain the same, then the water moves uniformly. The fall h is employed only to overcome the resistance in the bed, and we have

$$h = \mu + \frac{l\,\eta}{a} + \frac{c_2}{2\,g}, \text{whence}$$

$$c = \sqrt{\frac{2\,g}{\mu} \times \frac{h}{l} \times \frac{a}{P}}$$

in which μ is a coefficient found by experiments, and p the water perimeter.

According to Egtelwein and Buat $\mu = 0.0081$. Substituting this rule, and for $g = 9.809$ metres, we have for the metric system

$$c = 49.2 \sqrt{\frac{h}{l} \times \frac{a}{P}}$$

The coefficient of resistance μ is not quite constant, but decreases with a greater and increases with a less velocity. Weisbach makes

$$\mu = 0.007409 \left(1 + \frac{0.05853}{c}\right).$$

In the construction of canals the cross-section must be so chosen that the fraction $\frac{P}{a}$ becomes a minimum; hence the perimeter must become for a given area a minimum, or the area for a given perimeter a maximum.

In canals the cross-section is usually a rectangle or a trapezoid, which being given, the water perimeter must become a minimum.

Making the basis of the rectangle y, and the altitude x, then will

$$(1)\ a = x\,y \text{ and}$$
$$(2)\ p = y + 2\,4 \text{ or}$$
$$p = \frac{a}{x} + 2\,x.$$

Changing x into $x + \triangle x$, where $\triangle x$ denotes a very small number, and developing, we have

$$p' = \frac{a}{x} + 2\,x + \triangle x \left(2 - \frac{a}{x\,2}\right) + a \frac{\triangle^2 x}{x\,3} + \ldots$$

If this value of p' is to increase now for any positive or negative value of $\triangle x$, we must have

$$2 - \frac{a}{x^2} = 0, \text{ whence}$$

$x = \frac{1}{2}\sqrt{2\,a}$, and substituting this in eq. (1) $y = \sqrt{2\,a}$, *i. e.*

The altitude of the rectangle must be equal to one half its base, or the cross-section is to be half of a square the side of which is equal to $\frac{1}{2}\sqrt{2\,a}$.

For a trapezoid in which the area a and the angle β of the side slope are given, we have

$$(3)\ a = \left(\frac{2\,y + 2\,x.\ \text{cos. } \beta}{2}\right) x \sin \beta \text{ and}$$
$$(4)\ p = y + 2\,x$$

in which y is equal to the lower base, and x to the length of the side slope.

Expressing y in terms of x, equation (4) becomes

$$p = \frac{a}{x \text{ sin. } \beta} + x\,(2 - \text{cos. } \beta) \text{ and}$$

for $p' = x + \triangle x$ we have

$$p' = \frac{a}{x \text{ sin. } \beta} + x\,(2 - \text{cos. } \beta) + \angle\, x\,(2 - \text{cos. } \beta - \frac{a}{x^2 \text{ sin. } \beta} + a \frac{'\triangle^2 x}{x^3 \sin \beta} + \ldots.$$

And as condition for the minimum

$$2 - \text{cos. } \beta = \frac{a}{x^2 \text{ sin. } \beta}, \text{ whence}$$

$$x = \sqrt{\frac{a}{\text{sin. } \beta\,(2 - \text{cos. } \beta)}}$$

and

$$y = \frac{2\sqrt{a.}\ (1 - \text{cos. } \beta)}{\sqrt{\text{sin. } \beta\,(2 - \text{cos. } \beta).}}$$

Making the angle of the side slope 60°

$$x = y = \tfrac{2}{3}\ \sqrt{a.}\ \sqrt{3}.$$

III. *Unequal motion of water in rivers.*

When the average velocities in the different cross-sections are unequal the motion of the water will not be uniform.

In this case we suppose a certain distance of the river to be divided into smaller parts, for each of which the area a of the cross-section, the perimeter p, and the velocity v, may be considered constant.

Let v be the velocity at the beginning of such a part, v_2 the same at its end, l the length of the part, h the fall, corresponding to l, then will

$$h + \frac{v_1^2}{2\,g} = \frac{v_2^2}{2\,g} + \frac{\mu\,p\,l}{a} \times \frac{v^2}{2\,g}, \text{ whence}$$
$$(1)\ h = \frac{v_2^2 - v_1^2}{2\,g} + \frac{\mu\,p\,l\,v^2}{2\,a\,g}$$

Designating by a_1 the first, and by a_2 the second cross-section of the distance, l then is

$$a_1\,v_1 = a_2\,v_2 = a\,v\,; \text{ whence}$$
$$v_1 = \frac{a_2}{a_1} v_2$$

and substituting this value in eq. (1), we have

$$(2)\ h = \frac{v_2^2}{2g}\left[1-\left(\frac{a_2}{a_1}\right)^2\right]+\frac{\mu p l v^2}{2 a g}.$$

The correctness of this formula which is used for the motion of water in rivers increases with the decrease of l.

Introducing in eq. (2) the quantity Q of the water discharged, instead of the velocities, we have since

$$Q = v_1 a_1 = v_2 a_2 = v a$$

$$h = \frac{Q^2}{2g}\left[\frac{1}{a_2^2}-\frac{1}{a_1^2}+\frac{\mu p l}{a 3}\right], \text{ whence}$$

$$Q = \frac{\sqrt{2gh}}{\sqrt{\frac{1}{a_2^2}-\frac{1}{a_1^2}+\frac{\mu p l}{a^3}}}$$

Making in this last formula

$$a = \frac{a_2+a_1}{2}$$

then eq. (3) becomes

$$Q = \frac{\sqrt{2gh}}{\sqrt{\frac{1}{a_2^2}-\frac{1}{a_1^2}+\frac{8\mu p l}{(a_2+a_1)^3}}}$$

Designating the upper depth by m_1 the lower by m_2, the angle of the bottom by δ, then is

$$h = m_1 - m_2 + l \sin.\ \delta, \text{ and}$$

$$m_1 - m_2 + l \sin.\ \delta = \frac{Q^2}{2g}\left[\frac{1}{a_2^2}-\frac{1}{a_1^2}+\frac{8\mu l p}{(a_2+a_1)^3}\right]$$

This gives for that value of l which corresponds to $m_1 - m_2$.

$$l = \frac{m_1 - m_2 - \frac{Q^2}{2g}\left(\frac{1}{a_2^2}-\frac{1}{a_1^2}\right)}{\frac{8\mu p}{(a_2+a_1)^3}+\frac{Q^2}{2g}-\sin.\ \delta}$$

If $a_1 = m_1 l$; and $a_2 = m_2 l$; *i. e.* the width of the river being constant, we have

$$l = \frac{m_1 - m_2 - \frac{Q_2}{ag}\cdot\frac{m_1^2-m_2^2}{m_1^2-m_2^2-b_2}}{\frac{1}{(m_2+m_1)^3}\cdot\frac{8\mu p}{b^3}+\frac{Q^2}{2g}-\sin.\ \delta}$$

Substituting for Q its value

$$Q = m_1 b v_1$$

we have

$$l = m_1 - m_2 \cdot \left(\frac{1-\frac{v_1^2}{2g}\cdot\frac{m_2+m_1}{m_2^2}}{\frac{8\mu p}{l(m_2+m_1)^3}\cdot\frac{v_1^2}{2g}-\sin.\ \delta}\right)$$

For small values of l we can suppose

$$m_2 + m_1 = 2 m_1$$
$$= 2 m_2, \text{ whence}$$

$$l = m - m_2 \times \left(\frac{1-\frac{v_1^2}{2g}\times\frac{2}{m_1}}{\frac{\mu p}{m_1 b}\cdot\frac{v_1^2}{2g}-\sin.\ \delta}\right).$$

FILTRATION OF TOWN SEWAGE.

From "The Builder."

The new Royal Commission, appointed in 1868 to inquire into the best means of preventing the pollution of rivers, took up the subject where the former Commission had left it,—that is, after the Thames, the Lea, and the Aire and Calder basins had been reported upon, and have now issued their report on the Mersey and Ribble basins. They come to the same conclusions as the former Commission did in respect of the irrigation of land with town sewage being the best means of preventing the pollution of rivers with it, as well as being the most profitable in application; but they state the case in a different way to that in which the former Commission put it. They say that sewage may be sufficiently purified to be allowed to flow into any river or other watercourse, from which it is not intended to take water for domestic use, by *filtration* through sand or porous soil, as distinguished from the view that some persons take of irrigation, which is, that the sewage is purified by running over the surface of the land in a thin sheet, parting with some of its manurial elements to the plants, and storing the remainder in the top soil for the use of the next crop, or rather for the use of the crop first sown after re-ploughing the land; whereas the present Commissioners say that it is the filtration through a sufficient thickness of sand or porous soil that constitutes the efficiency of this method of utilizing sewage; and that therefore, its purification is insured by passing it through constructed filter-beds equally well as by passing it through the natural soil of the land. This they have ascertained by experiments with several kinds of soil, with sand, and with sand mixed with coarsely powdered chalk.

The difference between filtration through constructed filter-beds and through the soil of the land is one not of efficiency of purification, but of the profitable application of the sewage, the former method being unremunerative, while the latter is remunerative. But it is consolatory to know that in places where land cannot be had for irrigation, the sewage may yet be sufficiently purified to be allowed to flow into rivers, although the value of the solid part of the sewage which is retained may not be of much value. The value of it will evidently depend on the quickness with which it can be extracted in respect of the length of the time elapsing from its entry into the sewers to its extraction at the outfall. Where the gradients are considerable, and the mean distance of the outfall from the town is not very great, it may be arrested in a fresh state ; and, mixed with street sweepings and other town refuse, may become of considerable value ; while, where the gradients are slight, and the outfall at a greater mean distance from the town, it may become so far decomposed in its transit as to be of no value as a manure.

The Commissioners estimate that for a town where water-closets are in general use (therefore requiring a larger area than would be required where they are not so numerous), 5 acres of filtering surface, and a depth of material of 6 ft., are sufficient for a population of 10,000. According to their experiments something of this depends on the nature of the soil or other material used for the filter-bed, the qualities of various soils for this purpose differing ; for while soil procured from Dursley, in Gloucestershire, purified sewage at the rate of 9.9 gallons per cubic yard per day, soil from Hambrook, near Bristol, did not satisfactorily purify more than 4.4 gallons per day per cubic yard. Again, soil from Beddington purified sewage of the same strength at the rate of 7.6 gallons per day, while that from Barking did not purify it at a greater rate than 3.8 gallons, or peat from Leyland Moss, near Preston, at a greater rate than 4 gallons per day per cubic yard of material.

Considering that "filtration" has already often been employed to purify sewage, and has always hitherto failed, it is rather startling to see it so confidently recommended, until we remember that both the methods of filtration that have failed for sewage also failed for water many years ago ; that is to say, the horizontal method and the upward method, while, as soon as the late Mr. James Simpson re-arranged the filter-beds of the Chelsea Waterworks at Thames Bank many years ago, and made the water to descend instead of ascend through the filtering medium, the question was then and thereafter settled as to whether water should be filtered upwards or downwards. Every engineer since that time—every engineer, that is to say, who has had the knowledge to perceive the difference between a true and scientific and a false and empirical method, or who has had the honesty to acknowledge that he was not the inventor of the practice he has adopted,—all these men have adopted the downward system of filtration of water. And so we find the Commissioners—or, shall we rather say, Dr. Frankland, one of them ?—condemning the system of upward filtration now in practice at Ealing, and giving the reason why downward filtration is so effective in purifying sewage. The system at Ealing is to force the sewage upwards through a filtering medium constantly, thereby effecting no proper purification at all ; but by making the sewage to descend for six or twelve hours through one bed, then shutting it off from that bed, or compartment, and turning it on to another for a like space of time, and so alternately, the descent of the sewage through the interstices of the material on either bed is followed by atmospheric air ; the air, that is to say, that occupied these interstices before the sewage began to descend and has been used up in oxidizing and transforming, and therefore purifying, the former quantum of sewage, is replenished after the descent of each quantum of sewage through each bed, and so by continual periodical renewals of the proper aëration of the filtering medium, it becomes a constant purifier of the sewage ; for, although this method of filtration in the case of water has mostly been called a mechanical one only, yet, in the case of sewage filtration, the same method is said by the Commissioners to be both mechanical and chemical.

In order that there should be no ambiguity about what they recommend, and its attainment, they give a standard of impurity beyond which they think the water of sewage ought not to be admitted into

rivers or other watercourses. They suggest that the following liquids be deemed polluting and inadmissible into any stream :—

"Any liquid containing, *in suspension*, more than 3 parts by weight of dry mineral matter, or 1 part by weight of dry organic matter in 100,000 parts by weight of the liquid.

"Any liquid containing, *in solution*, more than 2 parts by weight of organic carbon, or .3 part by weight of organic nitrogen, in 100,000 parts by weight.

"Any liquid which shall exhibit by daylight a distinct color when a stratum of it, 1 in. deep, is placed in a white porcelain or earthenware vessel."

So far the standard is applicable to any town. But the Commissioners, having before them the question primarily of the pollution of the rivers Mersey and Ribble, which traverse the manufacturing part of the county of Lancaster, found it necessary for that district to prohibit—suggest, rather, that they should be prohibited—many kinds of pollution peculiar to the manufactures of those parts, *e.g.* :—

"Any liquid which contains, *in solution*, in 100,000 parts by weight, more than 2 parts by weight of any metal except calcium, magnesium, potassium, and sodium.

"Any liquid which contains, whether *in solution or suspension*, in chemical combination or otherwise, more than .05 part by weight of arsenic.

"Any liquid which, after acidification with sulphuric acid, contains, in 100,000 parts by weight, more than 1 part by weight of free chlorine.

"Any liquid which contains, in 100,000 parts by weight, more than 1 part by weight of sulphur, in the condition either of sulphuretted hydrogen or of a soluble sulphuret.

"Any liquid possessing an acidity greater than that which is produced by adding 2 parts by weight of real muriatic acid to 1,000 parts by weight of distilled water.

"Any liquid possessing an alkalinity greater than that produced by adding one part by weight of dry caustic soda to 1,000 parts by weight of distilled water."

The opinion of the former Commission was that sewage could not be filtered. "As applied to sewage, disinfectants do not disinfect, and filter-beds do not filter," they said. Sewage applied constantly to a filter-bed on the upward system does not purify sewage continually, certainly; and if that was the system meant to be understood, the former Commission were clearly right in their statement, but on the downward system the case is different. Any one who remembers the condition of the Thames when the Lambeth Company took their water from a point of the river near Hungerford Bridge, and when the Chelsea Company took their supply from Thames Bank, may well compare the water then taken from the river for the supply of a large part of London with the town sewage of to-day. The reports of the engineers were constantly that the water was "turbid;" but that word, as now used sometimes to define the condition of the Thames water, conveys no idea of the state of the water at that time. In comparison with the turbidity now sometimes said to exist, it might be called pea-soupy, or sludgy, and yet this very foul water was passed through filter-beds on the banks of the river, after subsidence in reservoirs, and transformed into the brightest and most pellucid water, as drawn from the filtered water well. No doubt the surface of the filter-beds often required cleaning; the mud deposited soon stopped up the pores of the sand so that no more water would pass, and this necessity of frequent shutting off and turning on of the water may have been the cause, as illustrated by the view the present Commission take of the subject, why these filter-beds were so perfect in action under such difficult circumstances; the air filling the interstices of the filtering medium—sand and gravel—after the mud was scraped from the surface of the sand, was replenished at short intervals, and so kept the filter-bed continually perfect.

Manchester being within the water-shed of the river basin inquired into by the Commission, it became necessary for them to institute an inquiry into the merits of the privy and ash-pit system, as against the water-closet system, especially as that city is the great stronghold of this first-named system.

Agreeing with every other impartial inquiry into this subject, the present Commission condemn it. They illustrate the case in a remarkable way. They suppose all dwelling-houses, warehouses, etc., to be removed, and only the privies left—nearly 60,000 of them in Manchester and Salford—rows and streets, and crowds of them—

scattered about almost as thickly in places as the heaps of manure upon a field that has just received a dressing from the dung cart—each heap here, however, no mere barrow-load once a year, but a constant collection and continual soakage of filth, which has for years been polluting every corner to which air or water could have access. *Is this the site on which to build a healthy town?* Would it not be the first desire of every sensible man to sweep this filth away, to drain and aërate, and, if possible, to sweeten this land before a single dwelling-house should be built?

On the great question of establishing a River Conservancy Board, the present Commissioners agree with the recommendations of the former Commission, to the effect that it is highly desirable that such a Board should be established for every river basin; but on the secondary question of how and of whom it should be constituted, the chairman, Sir W. Denison, does not agree with his colleagues, Dr. Frankland and Mr. John Chalmers Morton, and on that subject they give separate reports. The chairman advises a parochial system; that the officers of such parishes as the stream flows through should be the persons responsible for the state of the river flowing through their respective districts, but, anticipating abuse of the powers placed in their hands, he recommends that they be made sufficiently responsible to the general government to enable the latter to check or prevent any such abuse, or to notice and reprove, and even to punish all negligence or unfairness in the mode of action of the former. The initiation of action is to be the complaint of neighbor against the conduct of neighbor.

Let us take a supposititious case, and inquire how this would be likely to work in practice. Suppose two of the uppermost mills or towns on a stream to use the water that comes to them with satisfaction to themselves, but that one or both of them foul it so as to be unsatisfactory to the third person or town, the one below them. Of whom is the third party to complain? And, of course, the difficulty is increased if three or more parties are satisfied, and the fourth or fifth complains.

The boundary of the district over which each parochial Board is to have jurisdiction being conterminous with that of the parish, how are the officers of the parish injured to determine who above them has caused the injury? If all are complained against, who shall determine the degree in which each has contributed to the pollution of the river?

Dr. Frankland and Mr. Morton recommend that, inasmuch as there exist at present no local bodies competent to deal with questions connected with efficient river conservancy, capable of detecting pollutions and enforcing remedies, it will be necessary to call into action an authority possessing greater capacities and powers than those of the existing corporate bodies or local boards. The duties of this authority would be of two distinct kinds: the one would be those of a river police, employed in the detection of offences, and in obtaining the conviction of offenders; the other would include the investigation of and decision upon various works connected with rivers, proposed by either towns or individuals, such as schemes for water supply and for the defecation, filtration, or utilization of sewage and other polluting matters, while local boards could obtain information on these points only capable of investigating them. Nevertheless, under the second division of the duties of the central authority, the co-operation of the local corporations would be required for the efficient discharge of them. Indeed, if guided and assisted by a properly qualified central court, the present local boards would be quite competent to meet all local difficulties and to supply all local wants. A central authority would not extinguish the corporations and local boards at present existing in the river basins. It would, the Commissioners believe, materially promote the energy of local action by removing the obstacles which at present hamper it, and by giving a prompt decision to the questions which it has to solve.

A return has just been published showing the quantity of guano used in Austria, in each year from 1861 to 1869. In 1861 it was 12,819 cwt.; in 1862, 13,370 cwt.; in 1863, 18,650 cwt.; in 1864, 35,264 cwt.; in 1865, 45,264 cwt.; in 1866 (the year of the war with Prussia), 23,846 cwt.; in 1867, 63,446 cwt.; in 1868, 67,684 cwt.; in 1869, 106,514 cwt. The above figures include the guano used in Hungary.

THE JAPANESE RAILWAYS.

From "The Railway News."

We bow our head "one hundred times with profound respect" to Tanishokei Menamoto no Marasada. A century hence, when Yokohama produces its Samuel Smiles to record the history of the men who have done good service to their country, he will assuredly give a very high position to the gentleman whose name we have given above, and who is the author of an essay on the "Introduction of Railways and Telegraphs into Japan," and of petitions in favor of the same. Marasada is no ordinary man. He has taken up the question of railways and telegraphs after mature and careful deliberation. He is evidently a close observer and an able reasoner. He has already, as he states in his petition, "represented his humble views respecting the removal from circulation of the debased currency;" and it is possible that upon this matter he may have arrived at conclusions somewhat more sound than those put forward by our own Chancellor of the Exchequer for sweating the British sovereign. Marasada has, he tells us, also "occupied his private leisure in studying the constitutions of foreign countries, and here, too, he is profoundly ashamed." He has formed opinions which he is prepared to stand by at all risks. "Your servant," he says, "is willing to undergo beheading or boiling alive for his opinions. Those who do not know how stupidly honest he is, say that he is carried away by a love of what is new and strange." Men of progress nearer our own country have been subjected to precisely the same imputation. Hear, however, how the man of progress in Japan puts his enemies to the rout :—

"It is his humble opinion that the old exclusive spirit is still alive, and that the vicious habit of taking superficial views is not yet eradicated. Narrow views, such as might be held by a frog that lives in a well, are daily becoming more and more rife, and they not only find a vent in everyday conversation, but are boldly proclaimed in high official quarters. These persons are an obstacle to the progress of civilization, and injure the wealth and power of our country. They do not know that in order to defend ourselves against the foreign barbarians, whom they so much detest, the wealth and power of Japan must be the chief means. Such persons are really anxious to return to the old state of things, when men lived in hollow trees and caves like beasts."

While anxious, however, to see great reforms carried out in his country, Marasada is at heart a good and sound conservative. Were he in this country he would be classed among the Liberal-Conservatives of our political party. "It is the prayer of your servant," he writes, "that the great principles of the Constitution may be maintained, that attention be not drawn off to petty advantages or shallow sentimentalities, but that, regardless of the remonstrances of such men, a decisive order for the introduction of railways be given. Then the people of Japan will have placed before their eyes the advantage of this invention, and the proverb that 'to see once is better than to hear a hundred times' will be exemplified. When the railway has been constructed machinery of all kinds can be introduced, commencing with appliances for the cultivation of the mulberry tree, the silk culture, weaving, and for cleaning rice. Thus will a great stimulus be given to production, and foreign gold and silver made to flow towards Japan. If, under present circumstances, the railway project should fall to the ground, from a dislike to the trouble of carrying it into execution, your servant fears that the results to the empire will be calamitous." Well argued, Marasada! and your opinions have all the more weight, seeing that they are those expressed by one of the old Court nobles of Kioto, from whom, as from the old-fashioned Tories of our own country, such sentiments were by no means to be expected.

The opinions of Marasada are also shared by some other members of the Japanese Government, and a paper just presented to Parliament on affairs in Japan gives us "An Essay on the Introduction of Railways and Telegraphs into Japan," and a "Proposition for the Creation of a source of Wealth for the Promotion of the Imperial Felicity, and the Establishment of an Unlimited and Ever-

lasting Benefit to the Nation." The author of this essay complains that "the energy of the people is on the decline, the national debt is on the increase, and the voice of the poor in their misery fills the streets; the people of the towns through which the high road runs are poor and suffering in their unmitigated misery. Their old parents are neglected, and mothers cannot marry their daughters." As a remedy for this state of things, railways and telegraphs are suggested, and those who object to the introduction of such new-fangled things, on the ground that they would only "astonish our people's eyes and frighten their ears," are compared to persons of narrow views and small minds who "look at heaven through a hole in a small bamboo."

"I maintain," writes the author, "that the future of a country lies in its people, and the way to enrich the people is to encourage the productions of industrial labor. In these efforts the economy of human labor is of paramount importance. This is only possible by the introduction of telegraphs and railways. If a proof for this assertion is wanted we need only look to the condition of those nations which we now call great and highly civilized, say England or France, and a hundred years ago, when they had not been able to overcome the disadvantages of an exclusive employment of human forces for labor of all kind. Since the introduction of railways and telegraphs into those countries a hundred other useful and profitable discoveries have been added, the distances of thousands of miles are now traversed by horses and wagons or boats in a moment. Government dispatches its orders in all directions with celerity and promptness. Thus have the present wealth and power of those countries been created."

In conclusion, writes this Oriental philosophical statesman :–

"Let us hope that these objects may be obtained, and that they may become the source of our national prosperity, and promote the Imperial felicity. We may then say in truth that the basis of our independence and liberty as a free nation was the introduction of telegraphs and railways."

A second minute on the advantages to be gained from the construction of railways points out that, if made, places now at a distance would

"Become neighbors, and, as it were, one continuous street. Aged men, women, and children would travel with ease, and trade would become more and more flourishing. In future, chair-bearers, horse-boys, boatmen, and innkeepers will reap the benefit of the increasing prosperity, and they will be able to find some means of gaining a livelihood. For the present the execution of this great undertaking will afford employment to large numbers of the lower class in Yeddo and the vicinity, and give them the means of supporting themselves. This will naturally accustom them to the idea of a railroad, and thus the way will be prepared for its future extension, as above proposed, to the other provinces."

A despatch from Sir H. Parkes to the Earl of Clarendon announces the success which has attended these endeavors to enlighten the Government on these subjects, by the authorization of the Japanese railways, the capital for which has already been provided in this country. In this despatch Sir H. Parkes says it is essential to the establishment of a vigorous and compact administration under the new constitutional system, and of equal importance to the interests of commerce and the industry of the people, that improved means of communication should be provided. Japan, unlike China, does not possess navigable rivers; the rate of travelling averages only 20 miles a day, and provinces that are separated by 400 or 500 miles are at nearly a month's distance from each other. The two capitals of Yeddo and Kioto, though connected by the best line of road in the country, are a fortnight's distance apart, and the difficulty of transporting rice often exposes one part of the country to scarcity and distress while another district may be wanting an outlet for its produce. At the close of last year Sir Harry was informed by the Government that they had resolved to construct a railway between Yeddo and Kioto. Their difficulty in making a commencement lay in the want of funds, and this was met by an offer on the part of Mr. H. N. Lay, formerly of China, and who was then visiting Japan, to lend the Government £1,000,000 sterling, on the security of the projected line of railway and the Customs revenues. This offer he

accepted, and Mr. Lay returned to England to raise the above sum, and to engage the necessary engineers for the work. These are to be employed by the Japanese Government, under the direction of Mr. Lay, who has the right of superintending the construction of the railway, though all the plans and details have to be approved by the Japanese Government. The measure was strenuously contested by the party opposed to progress, and also by those who were unable to appreciate the advantages of the innovation; but the Government gave evidence that the question was fairly understood by its advocates, and Sir Harry now feels assured that the execution of the scheme may be proceeded with, and that, as the chief engineer, Mr. Morel, has reached Japan, they intend that he shall at once commence to survey the line between Yeddo and Yokohama. In the same despatch it is mentioned that an experimental line of telegraph, constructed by Mr. Brunton, is already working between Yeddo and Yokohama. Many Japanese foretold failure. It was believed the wires would be constantly cut, and in the popular mind the enterprise was connected with necromancy and Christian propagandism. The only injury done, however, has been some hacking of the posts by two-sworded roughs; and the single wire is now found scarcely sufficient to meet the demand for the transmission of Japanese messages between Yeddo and Yokohama. Mr. Brunton is consequently engaged in putting up a similar line between Hiogo and Osaka.

VARIABLE EXPANSION GEAR FOR WINDING ENGINES.

From "The Mining Journal."

An important invention, connected with the working of mines, is described in the French coal-trade paper, "La Houille." It is generally admitted that the application of expansion gear to engines insures an important economy of fuel, yet hitherto winding engines have been worked without it. The many conditions to be satisfied render it, indeed, difficult to apply, and cause mine owners who use unsalable debris for the raising of steam to hesitate before adopting it. But special circumstances have now made its application unusually desirable—the want of boiler space consequent upon the daily increasing activity at the pits. Thus, obliged as they would be to buy new boilers, it has been deemed preferable to utilize to a greater degree the steam already at their disposal, by causing it to produce more useful work by using it expansively. This secures not only the advantage of diminished consumption of fuel, but also renders available part of the boilers, the number of which had become insufficient. The question has been most successfully solved by Mr. Audemar, the engineer of the Blanzy mines. After having successively tested and rejected fixed cut-offs, as well as several special arrangements proposed to him, Mr. Audemar hit upon a form which was first tried for six consecutive months upon an engine of 250-horse power, and then, having succeeded perfectly, to six other engines of similar power, which were previously worked without a cut-off, and which now work with the greatest regularity on the works of the Blanzy Company.

The conditions which experience had proved to be necessary were—to work the machine with the expansion gear, and to be enabled to suppress the action of the cut-off instantaneously, when desired; to render unnecessary the attention of the engineer, who has already enough to attend to; not to increase the number of levers he will have to work, nor the power necessary to work them; and to make the cut-off variable, so as to adapt itself to the variations of resistance of the load to be raised. The apparatus consists of a double cam, one-half of which serves for the forward stroke, and the other half for the back stroke. Each portion of this cam has varied profiles, so as to give the various degrees of expansion, from the smallest to the greatest; and it is so disposed that the middle becomes the neutral point, like that of the Stephenson slide, and corresponds, like it, to no admission whilst the too extreme points give full open.

A valve on the Cornish system, placed before the ordinary distribution of the machine, is used to produce the expansion of the steam. This valve is put in motion by the cam, the rotation of which is caused by the gearing on the shaft of the engine, and it opens and closes according as one or other part of the cam is for the time being in operation. If the Stephenson slide be at its neutral point, the cam would be in a similar position, and the two being set in motion by the same lever, will at the same time occupy the extremes of their course. If, then, the engineer inclines his reversing lever, the several profiles of the cam being presented to the valve, produce a corresponding cut-off, which will become absolutely none if the lever be pushed full home. Thus, the mere inclination of the lever which the engineer already uses, suffices to produce the desired effect both for the forward and backward movement.

An essential feature is that the objections to the Stephenson slide when not at the extremities of its course are avoided. The connection of the slide with the cam is, in fact, made by intermediate sectors, so that the speed of the two parts is widely different. Thus the slide always occupies the end of its course, and gives the maximum opening to the ports, although the cam is sufficiently advanced to produce considerable expansion. The system, which appears to be free from complications, and which has been practically applied, has enabled the Blanzy Company to dispense with the purchase of boilers, which had become indispensable, and to secure in addition a saving of fuel equal in some cases to 40 per cent. And they were enabled in one case of four boilers already over-worked to put one out, for the purpose of cleaning. These results are so remarkable that the general adoption of the invention is confidently anticipated; and, as all the parts are ready made, the stoppage for a single day is sufficient to apply the arrangements to existing engines; and they, moreover, meet the approval of the workmen, because they do not at all interfere with their existing habits.

There are in the United States 48 manufacturers of railway cars. Seventeen of these are in Pennsylvania.

It is proposed at present to construct just 134 miles of street railways in the metropolis, but Mr. Haywood remarks that if the experiment be successful, not only London, but all our large towns, and not only our towns, but many of our country roads, will be traversed by these lines; that steam power will soon be substituted, in all probability, for horse power; and that, "unpleasant as the notion may now seem to us," we shall soon have engines dragging omnibuses along our streets.

Sleigh bells are attached to the points of the carriages on the Liverpool tramways to warn vehicles to get out of the way, which they are said to do very easily, even in the narrowest streets. The whole of the rails in the streets of Liverpool were laid in the night time, under the superintendence of an officer of the corporation, and the traffic was not interrupted for a single hour. Could not this be done in London?

A Moscow journal states that the railway bridge lately erected over the Dnieper, near Kiew, is one of the greatest works of the kind in the world, and the longest in Europe. It consists of 12 arches, and is 3,503 ft. in length. Capt. von Struve, who built it, has been promoted to the rank of colonel by the Emperor Alexander, on the recommendation of the Minister of Public Works.

It is estimated that, in round numbers, 110,000 tons of steel rails, equal to 1,100 miles of steel road, were laid in the United States up to the close of 1869. These rails are in use on more than 50 roads, chiefly of English, partly of American, and some of Prussian manufacture.

Pure silver, if highly heated in oxygen, will absorb 6.15 to 7.47 volumes of that gas, and under the same circumstances will take up 0.907 to 0.938 volumes of hydrogen, 0.486 to 0.545 carbonic acid, and 0.15 carbonic oxide; in this property it differs considerably from palladium.

THE CONVEYANCE OF SEWAGE.

From "The Engineer."

The best means, and those most efficient in a sanitary point of view, by which to accomplish the removal of the sewage of large cities and towns, have not yet been decided upon in that definite and conclusive manner which ought to characterize all the arrangements connected with matters of national importance. So far as the metropolis is concerned the question is virtually settled; but the different systems that prevail in Liverpool, Manchester, Dublin, and other cities possessing large populations, indicate unmistakably that great diversity of opinion exists on the subject. There is little doubt that, in many instances, the adherence to any one particular plan of operations is due solely to the circumstance that a town or district has committed itself to that plan, and prefers continuing to use it rather than submit to a troublesome and inconvenient change. This is by no means an uncommon thing in numerous other matters with respect to municipal and local jurisdiction. Without entering into the details of the various methods proposed, patented, experimented upon, and rejected, it will be sufficient to class them as all included under one of two general principles. The first is that which effects the removal of sewage by water carriage, that is, by sewers and drains; and the second comprises all other means and agencies not comprehended in the former. Briefly, these two systems may be appropriately termed the water carriage and the non-water carriage systems. The fact that London stands committed to the water carriage principle does not necessarily imply that that is the better of the two, or that others possess no merits or advantages of their own. It is only after an impartial and deliberate investigation of the separate systems that a fair estimate can be made of their respective value. A large amount of interesting and, what is more to the point, reliable information on this subject has been obtained by the Rivers Pollution Commissioners, and placed before the public in their recent report. The candid and disinterested manner in which these gentlemen conducted their inquiry sufficiently proves that they had no other object in view save the elucidation of the truth, and effecting a thorough and stringent investigation into every fact that had a proper and significant bearing upon the matter at issue.

It follows as a necessary consequence that wherever the water carriage system is in operation, the houses are supplied with closets, whereas in those instances in which another method of removing sewage prevails they are fitted with privies. What our own ideas, and those of the inhabitants of the metropolis, are with respect to the latter, would be truthfully represented if we could imagine our feelings on the supposition that every water-closet in London was removed and replaced by a privy. Nevertheless, in many towns and rural districts the introduction of water-closets is opposed with the greatest vehemence and hostility. So strong was this feeling at one time in Manchester, that when the corporation made an application to Parliament for the construction of water works, they asked for powers in their bill to enable them to levy one guinea per annum for every house subsequently provided with a water-closet. Whatever effect this might have had upon the superior classes of habitations, it would undoubtedly have totally prevented the introduction of the closet into those of an inferior description, where they are most needed. The argument most urgently and confidently put forward by the partisans of the non-water carriage system against the other is, that the latter directly pollutes and contaminates the natural watercourses of the country. It must be admitted that there is a great deal of truth in this assertion; but at the same time it is no valid argument against the water carriage principle, because, although the pollution of rivers and streams is unfortunately but too frequent a concomitant and a result of that system, it is not necessarily so. Were this pollution an inevitable consequence of the conveyance and removal of sewage by water, then that method would stand condemned, not only in a sanitary, but in every other point of view. But in reality this objection—which is specious even when examined theoretically—will, before long,

practically cease to exist. It has ceased to exist in many localities where its influence was widely extended and pernicious to the last degree. Owing to the stringent measures adopted, however tardily and reluctantly, by the sanitary authorities, some of our towns have adopted sewage irrigation, and no longer convert the nearest watercourse, as heretofore, into a wholesale receptacle for refuse of the most abominable description. If the report of the commission, to which we have alluded, receive that attention and consideration to which it is entitled in the cause of the public welfare, it will shortly be a penal offence to discharge sewage or refuse of any kind into any river or stream whatever.

When we investigate a little further the *pros* and *cons* of this question, it will be found that the opponents of the water carriage plan claim a complete immunity for their system from the evil which they allege accompanies the other. A few facts collected by the commissioners in evidence, which we shall presently advert to, proves this counter assertion to be utterly untrue. Omitting the pollution caused by manufactories and industrial establishments, as for the moment foreign to the comparison, the streams in the neighborhood of towns where privies were used instead of water-closets, were shown by analysis to be nearly as much contaminated as those which flowed through towns where the latter were employed. Theoretically the privy system will stand a favorable examination, but practically it proves wofully defective. If the cesspools were always water-tight, if they were at a proper distance from human habitations, if their contents were always sufficiently dried by the ashes thrown upon them, and if they were properly attended to and emptied when they required it, then possibly the soil, the air, and the stream might escape pollution. But how does the actual working of the principle bear out these very partial and one-sided suppositions? As facts, proved incontestably before the commissioners, the cesspools are not water-tight, are not at a sufficient distance from human dwellings, their contents are not dried by the ashes added to them, and they are not properly attended to and cleaned out at regular periods. Consequently the soil, the air, and the natural watercourses *are* polluted, the immunity from this evil assumed by the advocates of this method is devoid of foundation, and were we to inquire no deeper into the matter, there would be nothing to mark any relative superiority on either side. It would be to little purpose to mention a number of independent instances where the privy system is in full operation, and where, in order to abate the nuisance, it has been necessary to connect them with the town drains in order to get rid of their liquid contents. Let us select an example on a large scale, and one in which a very able and energetic local administration and strict police regulations prevail. Let us take the town of Manchester, where the management is very superior to that which prevails in places of inferior size and importance. In that town, among the poorer districts, the privies and ash-pits are in a chronic state of overflow and filthiness. Even in better parts of the town there are long rows of houses standing back to back, separated by an interval of only about 30 ft. This narrow passage is divided by a still narrower lane, on each side of which are the privies, one to each house, or sometimes in pairs; each pair having a common ash-pit. The emptying of these "middens," which includes twenty or thirty at a time, is accomplished at night, the contents being wheeled along the whole length of the narrow middle passage. Is it to be imagined that this can be done without poisoning and contaminating the air in the vicinity; or does the corporation suppose that because it is effected when people are asleep, and they do not perceive the abominable smell, that it is, therefore, innoxious and inoffensive? We may now allude to a circumstance in connection with this system which exhibits it in all its deformity, and displays its most revolting aspect. The scavengers divide the contents of the ash-pit into *wet* and *dry*. The former is conveyed, or rather imagined to be conveyed, to the manure depot; the latter is carted away to any convenient plot of ground which requires to be filled up—in a word, "where rubbish may be shot." To make this distinction between the wet and dry contents—or, under the circumstances, to attempt to make this distinction—is a practical absurdity, although there is little doubt that many would vigorously assert that it is made. These plots of land where rubbish may be shot, gradually be-

come filled up with this objectionable stuff; houses are built upon them, and is it a wonder that "typhoid fever, scarlatina, diarrhœa, and other zymotic diseases commit fearful ravages amongst the populations exposed to such pestiferous influences?" If this sort of foundation has been in vogue from early times, Manchester may be correctly described as a "collection of houses erected upon human dunghills." Not as an apology, but as a vindication of this forcible language, we quote the following brief paragraph from the report: "There is now a 'tip' in a ravine at Colyhurst, on the north side of Manchester, where the land is thus being raised *fifteen* to *twenty* feet over many acres, by the gradual accumulation of filthy rubbish." It may also be mentioned that the proof of what the rubbish consisted was readily arrived at by analyzing a sample of the water contained in a pool at the bottom of this tip, which fairly represented rain that had trickled through the disgusting mass. The average of two samples of this water contained in a hundred thousand parts 1976.95 parts of total solid matters in suspension, and was considerably richer in putrescible ingredients than any water-closet sewage which ever came under the observation of the commissioners. This explains the reason why it is so difficult to sell the so-called manure which composes the other parts of the contents of the ash-pits. It is, in fact, worthless.

Regarding the sewage question as consisting of two important features—the one the removal of the sewage from the vicinity of human dwellings, and the other its subsequent utilization — it must be admitted that the water carriage system effects the first in a manner that is impossible of achievement by any other means. There is no necessity of alluding to the superior cleanliness, and to the almost invisible agency by which this is accomplished, which are in perfect consonance with English tastes and habits. On the other hand, the rival principle does not remove the sewage from the neighborhood of human habitations; and, where it does accomplish this partially, it is by means that are highly offensive and injurious. With regard to the second part of the question, the non-water carriage method saves about four-fifths of the fecal matter of the population, mixes it up with a large quantity of ashes, and conveys it to the land at a much greater cost than it is worth. The water carriage plan carries the whole of the fecal matter away in a fresh condition, while that transported by the other plan is putrid. The *argumentum ad hominem* is usually regarded as an element of weakness in the party employing it. It is, however, sometimes singularly conclusive, and, applying it to our present comparison, it might be fairly stated that no one who had tried the water carriage system would for a moment entertain the idea of returning to privies and cesspools. But the same opinion does not prevail on the other side. On the contrary, the majority of those who have been condemned to endure the inconveniences and disadvantages attending the absence of water-closets would willingly adopt them, and place themselves under the same *régime* which makes London the best drained city in the world.

Spectrum analysis has been applied by Vogelsang and Geissler to the difficult question of determining the chemical nature of the fluid found inclosed, in minute quantity, in the cavities of certain quartz-crystals. Fragments of quartz, says the "Chemical News," were placed in a small retort, which was connected with an air-pump and exhausted; then, by the application of heat, the quartz decrepitated, and the evolved vapor was examined in a Geissler tube. The presence of carbonic acid was thus abundantly proved, and this was confirmed by the turbidity which it produced in lime water.

The French steamship company, Les Messageries Impériales, having to ship a quantity of ice to Suez, for the use of its steamers in the Indian Ocean, and desiring to find the best quality for their purpose, subjected 100 kilogrammes (220 lbs.) of several kinds to the same conditions of temperature, with the following results:—(1) Natural ice from Switzerland lasted 107 hours; (2) natural ice from Norway, 115 hours; (3) artificial ice made by the Carré machine, 130 hours; (4) natural ice from Boston, Mass., 138 hours; (5) artifical ice made by the Tellier machine, 144 hours. Artificial ice, then, appears to be as solid as natural ice.

MANUFACTURE OF IRON—ON PUDDLING.

By MR. RICHARD LESTER.*

From "The Mining Journal."

From the earliest period of history iron-workers have existed. Tubal Cain is represented as the first instructor of the artificer in iron, but it has been worked upwards of 5,000 years, and from time to time has had the greatest amount of skill bestowed upon it; but with all this the constituent elements of iron are still unknown. Yet sufficient knowledge is attained to make iron in such quantities that, for really useful purposes, it may be fairly ranked as the king of metals. To enlarge upon its adaptation would be to deal with every domestic article, tools, implements, weapons of defence and offence, the iron rod, the stately ship, the domestic sewing-machine, or the fisherman's hook. I will not further expatiate on the purposes to which iron is applied, but will at once proceed with the methods for its manufacture. The earliest mode of making iron handed down to us was by long and constant refining in a bath of melted oxide, until it would stand the compression of the hammer. Iron in the malleable form was the production of the early artificers, but we have no account of crude cast metal from the ancients. Of late years iron manufacture has made giant strides; the making of small quantities of malleable iron in the shallow hearth is superseded by colossal smelting furnaces, where the ores are reduced to the metallic state, combined with many impurities. The cast has to be wrought or puddled before it is what is termed malleable iron.

In the years 1783 and 1784 Mr. Cort, of Gosport, invented certain methods of puddling, a process by which iron was really made in larger quantities, and his invention proved of great value, both in his time and to the present generation, so much so that he is styled the father of iron works. Mr. Cort's process was to puddle the crude iron in reverberatory furnaces, and on sand bottoms. By your permission I will read Mr. Cort's process:—A common reverberatory-furnace, heated by coal, is charged with about 2½ cwt. of half-refined gray iron. In little more than half an hour the metal will be found to be nearly melted. At this period the flame is turned off, a little water is sprinkled over it, and a workman, by introducing an iron bar, or an instrument shaped like a hoe, through a hole in the side of the furnace, begins to stir the half-fluid mass, and divides it into small pieces. In the course of about 50 min. from the commencement of the process the iron will have been reduced by constant stirring to the consistence of small gravel, and will be considerably cooled. The flame is again turned on, and the workman continues to stir the metal, and in 3 minutes time the whole mass becomes soft and semi-fluid, upon which the flame is again turned. The hottest part of the iron now begins to heave and swell, and emit a deep-blue lambent flame, which appearance is called fermentation; the heaving motion and the accompanying flame soon spread over the whole, and the heat of the metal seems rather to be increased than diminished for the next quarter of an hour. After this period the temperature again falls, the blue flame is less vigorous, and in a little more than a quarter of an hour the metal is cooled to a dull red, and the jets of flame are rare and faint. During the whole of the process the stirring is continued, by which the iron is wrought to the consistence of sand; it also approaches nearer to the malleable state, and, in consequence, adheres less to the tool with which it is being worked. During the next half-hour the flame is turned off and on several times, and a stronger fermentation takes place; the lambent flame also becomes of a clearer and lighter blue, the metal begins to clot and become less fusible and more tenacious than at first. The fermentation then by degrees subsides, the emission of blue flame nearly ceases, the iron is gathered into lumps and beaten with a heavy-headed tool; finally the tool is withdrawn, and the aperture through which the iron was worked is closed, the flame again turned with full force for six or eight minutes; the pieces thus being brought to a high welding heat are withdrawn and shingled, etc.

* Read at the Cleveland Iron Trade Foremen's Association.

Although the above process made good iron, it had a very good metal to start with, well cleared from many of the impurities which we have to contend with now. But much of the iron was spoiled because of the inability of the workmen to regulate the action of the iron on the bottom of the furnace, it being formed of sand, which drained off the oxide, which was also detrimental to puddling. The next improvement on Mr. Cort's process was the substitution of iron bottoms to the puddling furnaces; and hereby the liquid bath of the oxide is retained by the iron, although the author of the iron bottom says it was the principal aim of his invention to work the iron in a bath of cinder; in fact, to boil it in a similar manner to the old process in charcoal fires. This part of the business was never carried out till Mr. Joseph Hall, of Bloomfield, Tipton, Staffordshire, brought it into practice. Mr. S. B. Rogers, who was the inventor of the iron bottom, never received much notice till his last years, when he received some gratuity from several of the Welsh ironmasters, but his work still stands, and to all appearances will be a lasting monument of his usefulness, although named "Mr. Iron Bottom."

You will here see that puddling has arrived at its present condition by slow stages, and improvements are being tried continually; but the elementary principle of puddling must be embodied in any scheme for the manufacture of iron, if it is to be a success. This is the process I have to treat with to-day, and it is performed as follows: The furnace is the reverberatory principle, the hearth at the bottom about 2 or 3 in. thick, and around, about 11 in. high, is coated with good oxides. When your furnace is hot enough to charge throw in your cinder or oxide which are found about your hammers or rolls; next charge the iron on the top of the cinder, the aperture of the furnace is closed, and the flame is put on. The charge is then melted in about 30 min., but during the melting the workman, with his rabble, breaks up the metal as it softens, and keeps it off the bottom. When the iron is sufficiently clear the damper is closed, which cools the surface and checks the iron from becoming too hot, and surcharges the furnace with carbonic oxide, which prevents the iron from throwing off its carbon till the whole mass of metal begins to heave and rise; the damper is withdrawn, and the flame put on; the iron is in a state of effervescence or boiling, as it is termed, and the whole of the exertion of the workman is required here to keep the msss well open with the rabble, so that the carbon combined with the oxide may freely escape. The fire upon the grate must be kept solid, and the flame full in every part of the furnace, because any free air passing through the furnace attacks the iron as it begins to come into its mature state, as it is called.

It is at this stage of the process that each granule of iron takes up a fresh existence. The boiling of the iron must be forced as much as possible to its issue to keep the iron from clotting before the carbonic oxide is burned out. It is also at this point that the cinder, with all its impurities, leaves the iron; hence it is necessary to keep the iron up, so that it shall be well wrought, and free from all deleterious substances. If the iron is not well boiled it falls into a crude or raw state to the bottom of the furnace, and if this be the case it is all but impossible to make wrought-iron of it afterwards. The iron being dropped, it requires the furnace still to be kept full of flame of a hot clear nature, but suited to the temperature that the iron will stand. The iron is now turned over from one side of the furnace to the other till it is sufficiently heated all through to adhere together, when it is formed into lumps, and taken to the hammer, and shingled and rolled into puddled bar. At this point it should be stated that although heat, especially a high heat, such as Bessemer attained during his decarburization process, is of the highest value, yet it should be borne in mind that any separation which takes place after the boiling ceases is only undoing what is already accomplished—the cementation of particle with particle by the combination of oxides. My opinion is this, that a chemical action has taken place before the iron is dropped, and this is where welding commences. That should never be disturbed, for all the carbon that is not required in the iron ought to be burnt out before the iron is settled down. The following is an analysis of the pig-iron previous to and after the Bessemer process: —The pig 1.012 bar, after 1.102; 2d, pig 1.090, after 1.960.

For the further guidance of those who

take an interest in puddling, I have drawn up a few rules which must be attended to when quality is required :— 1. Thoroughly melt your charge. 2. Keep it in the melted state some little time. 3. Add carbon by lowering the damper. 4. Keep the fire well up while the iron is boiling, and work well every part of the charge, so as to bring about a thorough union of the iron and cinder. 5. Lower your damper proportionately to the temper of your iron, ball up, and carefully prevent the air or fire-oxygen from passing through the furnace, for it will burn the charge. Inattention to this is the great cause of bad iron. And I now beg, in conclusion, to draw your attention to the analyses and tests of samples of puddled bar made from No. 4 Cleveland pig-iron, which have been brought about by adhering to the above whilst puddling. The hardest of the samples stood a strain of 38 tons to the square inch. B, the softer, stood 38.8 to the square inch. Now, as phosphorus is generally supposed to be the cause of the Cleveland pig not making a bar of ordinary strength, it was an anxious part of the business to know when it is taken out by the process of puddling, there being a suspicion that the mischief is done by the burning of the iron when it is dropped, rather than by the phosphorus. Besides, Dr. Percy says that the elimination of the phosphorus of iron is a problem of the highest practical importance, and that his opinion is that it comes away during the time the iron is sweating while being formed into lumps. It was necessary to try and find when it did escape. During the Bessemer process, which is similar to the boiling before mentioned in puddling, the analysis of the iron gives more phosphorus than the original pig-iron, and his iron was taken out before it had a chance of sweating. After-boiling shows only slight traces of phosphorus. Therefore it must eliminate at some stage previous, which must be during the melting. It must escape as phosphoric acid among the cinder, which is oxide.

From the Darlington Iron Company, Albert-hill Iron Works, Darlington, to Mr. R. Lester, forge manager, etc., Messrs. Hopkins, Gilkes & Co. (Limited):—"I got your sample bars to-day, but cannot think they are made from Cleveland iron only. I tested them very carefully at my leisure time, and find these extraordinary results to be from common stone. You will favor me with particulars, perhaps this next week. Test, etc., as below :—

"No. 1 bar = .88″ × .80″ = .7040″; broke at 25 tons; carried 24.5; = 34.8 per sq. in.

"No. 2 bar = .88 × .80″ = .7040″; broke at 25 tons; carried 24.5; = 34.8 per sq. in.

"Reduced in section at breaking part to .82″×.74″ =. 6068″.

"Yours truly, C. Thompson."

"Sample marked 'A soft'—phosphorus, slight trace. Sample marked 'B soft'—phosphorus, trace.

"Herbt. Crossley."

After the reading of the paper, a very interesting and animated discussion took place upon the different processes which iron underwent during puddling, in which Mr. Hopkins and Mr. Hill, of the Tees Iron Works; Mr. Thomas, of the Acklam Refinery; and Mr. Platts, the secretary, took a prominent part. Mr. Hopkins thought it very desirable to continue the experiments that Mr. Lester had made with pure Cleveland iron, and he hoped that other firms in the district would also make experiments in the same direction, with a view of carrying out the objects of the Association—the practical discussion of such papers. Mr. Thomas moved the adjournment of the discussion until the next meeting. The Chairman proposed a vote of thanks to Mr. Lester for his interesting paper, and stated that on Saturday next the session would close by an excursion to the Eston Mines.

The policy of harmonious working between the Grand Trunk of Canada and the Great Western of Canada line has been advantageously established; the continuous decline of the American gold premium still further promises to benefit the position of the Company. During the current year improvements effected in the rolling stock are likely to increase the traffic, and the progress of construction of the intercolonial line is expected during the coming summer to lead also to new business.

The railway between Bombay and Calcutta has been opened for through traffic.

GUNS VERSUS TURRETS.

From "The Engineer."

The policy pursued by successive Admiralty Boards in dealing with what is known as the turret question, has been so exceptional that it can hardly have failed to attract the attention of every one interested in the construction and armament of our own and other navies. For many years the British Government positively refused to use turrets in any shape or form, and it was only under a severe pressure of public opinion that Captain Coles was allowed, ultimately, to apply his inventions to the Royal Sovereign. This ship was, in a sense, a success, and the nation by degrees acquired possession of two or three other turret ships of small size, two of which, the Scorpion and the Wyvern, are anything rather than successful. At last the Captain was laid down, and Mr. Reed, apparently grown tired of designing and building broadside ships, gave us the Monarch, and proposes to give us the Devastation, etc.; and it is by no means impossible that for some years to come all our new men-of-war will, in some shape or other, be fitted with turrets on which they can rely for the protection of their guns and crews. Far be it from us to reopen any question concerning the relative merits of the broadside and the turret; we have a very different object in view in penning this article.

The tax-payers of England have never refused to place at the disposal of the Government for the time being large sums of money to be used in carrying out experiments in gunnery, or the construction of shields, forts, or even ships. At Shoeburyness almost every conceivable form of target representing a portion of a ship's side, or the wall of a fort, has been tested over and over again by every conceivable kind of gun, shot, shell, and powder. The lessons taught by these experiments are, beyond question, of enormous value. To them, indeed, we are mainly indebted for the possession of the best guns and the best armor-plated ships in the world. It is to be observed, too, that we have never adopted any invention of importance in guns or armor without first testing it elaborately, patiently, and for the most part fairly, with one exception, and that exception is the turret. It is possible that some good reasons can be brought forward to prove that it was unnecessary to test turrets with the fire of heavy guns, though all the other forms which armor can assume have been fired at over and over again; but if such reasons exist, we confess we know nothing about them. How is it that no complete turret with its turning gear, etc., has been put up at Shoeburyness and fired at till it was destroyed? We may be told that the experiment would have been too costly. This can hardly be the reason, because enormous sums have been spent in the construction of casemates and shields without the least hesitation, and the price of a turret would have very slightly augmented the annual expenditure on experiments, provided the testing of a few shields had been postponed. Of course it is impossible to test everything at once, and we may be told that in a little time the testing of turrets will begin; but we submit that the proper time to test them is before, not after, their extended adoption by the Admiralty. The moment it was decided that we should have turret ships it should also have been settled that shields and casemates should give way for the moment to the new scheme. Instead of this, however, we find that enormous sums have been and are about to be spent on a system, the suitability of which to its intended purpose has never been practically tested by the Government. If it be indispensable that shields, and sections of broadside ships, should be tested, surely it is equally essential that turrets should be experimented upon. The chief constructor will not put a belt on one of his ships unless he knows from past experiment what that belt may be expected to do in maintaining, under fire, the efficiency of the ship on which it is bolted. But he has no hesitation in fitting a turret to the same ship, about which, turret experiment tells him nothing whatever. It is nonsense to say that the belt is only tested because the testing does not cost much. If the test be required at all it should be carried out, whether it costs much or little. If it is only carried out because it costs little, then that little is so much money wasted.

Of course, the answer to our arguments is that there is so much in common between a turret and a ship's side that when we test the latter we really test the former; and also that the turret system has been tested—first, at the time that Capt. Coles brought out his cupola; secondly, in actual warfare, in America and elsewhere, and again on board the Royal Sovereign, against one turret of which ship three rounds were fired from a 300 lb. rifled 12½ ton gun, on the 15th of June, 1866, since which date—that is to say, within the last four years—notwithstanding our rapid advance in the construction of guns, no shot has been fired within the shores of England at a turret.

Now, in reply to these arguments, we submit, firstly, that although there is a great deal of resemblance between a section of a ship's side and a section of a turret, there is also a great deal of difference. A difference not nearly so great between 2 targets has, before now, secured the testing of each independently of the other. The argument cannot be pressed without charging the authorities with inconsistency, and we are disposed to think it never is pressed at all. The great point made by those who hold that the practical testing of the turret system is unnecessary is, that the Americans have tried the system fully, and that we have fired at the Royal Sovereign. If it could be shown that the results of those tests were conclusive, and in favor of the turret, we might rest content to admit that the no-test party had made out a very good case; but, in point of fact, the experience of the American War tells heavily against the turret system. The light guns of the Confederates disabled turrets in all directions. Mr. Eads, of the U. S. Navy, who was practically engaged in the construction of monitors for years, has recently published a letter most damaging for the advocates of the system, the fullest corroboration of which is furnished by official reports with which we are familiar. The experiment with the Royal Sovereign was precisely similar in character to that tried by Don Quixote with his helmet. The first shot went through the port, smashing the dummy gun to splinters. Had it been a shell instead of a shot every man in the turret would have been killed; of course, if a real gun had been there instead of a "quaker," the shot could not have got in; but then, how about the gun? Would it still have been serviceable? Another shot glanced, as it was not well aimed, and the third lodged in the backing. Had it been a shell, it would have ripped a great piece out of the turret. There is very little doubt that one 300 lb. shell fired subsequently, and striking fair, would have left the turret useless, but the shell was not fired. Every scrap of evidence available goes to show that the turret system, although possessing many admirable qualifications for warfare, is very far from having given results so satisfactory that it may be accepted as a whole without further experiment. On certain points in particular, information is required. If a shell struck a turret low down, and lodged in the backing, would it, or would it not, jam the turret by driving downward and outward a portion of its walls? If a 600 lb. shell passed through the breastwork with which Mr. Reed protects the bases of his turrets in the Devastation, etc., and exploded in the intervening space, what would be the result? How about the effect of shells dropped by vertical fire from rifled mortars into the same space? These questions are but a few of many which may be asked, and to which no answer can be given except that American experience proves that the results would be serious, if not disastrous, but that there is some ground for thinking that, after all, not much harm would be done. We are the last to advocate useless expenditure, but we hold that a moderate sum of money should as soon as possible be devoted to the construction and testing of a turret embodying all the latest improvements. Even if it were decided to construct this turret of only one-half the full size, reducing the attacking power in the same proportion, a great deal might be learned, although the experiment would not be quite so satisfactory, for obvious reasons, as it would be if carried out with the best turret and the best gun that England can produce.

THE Honduras Railroad is still progressing favorably, and it is believed that the section of road between Cortez and Santiago will be finished before the end of the year.

THE IRON AND STEEL INSTITUTE.

From "Engineering."

Amongst the numerous scientific associations with which engineers are professionally connected, the Iron and Steel Institute is one of the most recent origin. The short history of this society, however, is one of considerable importance with regard to the general progress of industry in this and in other countries, and there can be no doubt that the Iron and Steel Institute has, in the short period of its existence, succeeded in taking its place among the first and most powerful scientific bodies in the United Kingdom. This is due not only to the number of its members, and the influential position which the greater part of them occupy in all the different manufacturing localities of this country; but also to the great amount of practical experience at the command of the Institution for investigating and discussing questions of great practical importance, and to the enterprising spirit with which committees for scientific and statistical researches are appointed and endowed. All these, and many other minor points, are distinguishing features which cannot fail to produce the most important and beneficial results upon the progress of iron metallurgy, and of all branches of industry and engineering, while by a necessary and just reaction they tend to raise the position and estimation of the Iron and Steel Institute in the eyes of the public. At the meeting which was held at the Westminster Palace Hotel recently, a committee was appointed to report upon the question of mechanical puddling; while another committee was intrusted with the task of reporting upon the distribution of hematite iron ore in Great Britain. These investigations of subjects of such vast importance cannot fail to advance materially the position of the iron and steel trade in general, and the council of the Iron and Steel Institute deserves congratulations for having given the impulse to these investigations.

The technical questions under discussion at the last meeting comprised a subject which at present stands very prominently before the minds of iron masters and mill managers, namely, the question of reversing rolls as compared with double sets of rolls or "roll before roll," as this latter arrangement is generally termed. This subject formed the main point of the discussion upon the paper on improved machinery for rolling rails, read by Mr. Menelaus, of Dowlais. Reversing at high speed, say at more than 40 revolutions per minute, has for a long time been considered as an absolute impossibility by practical men. The momentum of the mass in motion, and particularly that of the heavy fly-wheel by which the constructors of rolling mills were accustomed to "get over" the insufficiency in direct steam power which they had provided for the work of the mill, were the well-known causes which actually rendered reversing at high speed impossible in past days. Mr. James Nasmyth, the well-known inventor of the steam hammer, made the first step in the direction which has been so successfully followed by Mr. Ramsbottom, of Crewe, and which resulted in the modern high speed reversing mill. Mr. Nasmyth removed the fly-wheel and suggested the reversing of the engine by means of the link motion. This idea, supplemented by Mr. Ramsbottom's ingenious reversing gear, produced what is now one of the best and most successful types of rolling mills in existence. Messrs. Tannett & Walker tried to arrive at a similar result by a reversing gear in which the transmission of power is effected by a friction clutch, which can be reversed with great facility and without causing any sensible shock, by means of a simple steam or hydraulic piston. The advantages and disadvantages of these reversing rolling mills, form a subject upon which opinions justly differ. The fact that the momentum of the large masses must be destroyed or overcome each time the machine is reversed, is a disadvantage which cannot be denied nor altered, however gently this absorption may take place, and however carefully all sudden jerks and concussions may finally be avoided. Reversing, therefore, undoubtedly means loss of power. On the other hand, the reversing rolling mill, when compared with the ordinary two-roller mill, saves nearly one-

half of the time in rolling forward and backward when compared with the "three roll mill," or with the well-known Dowlais mill, invented by Mr. Menelaus about 12 years ago. The reversing rolling mill saves a considerable outlay for additional rolls, or, what is still worse, additional length of rolls, and it also avoids the necessity of raising and lowering the end of the bar by the height of the diameter of the rolls after each passage through the rolls. A new form of rolling mill by Mr. Brown, was exhibited at the meeting by a model, this mill consisting of a double pair of rolls driven in opposite directions, and in which the working grooves of each pair of rolls are placed opposite to blanks or large recesses in the other pair of rolls. This mill has the drawback as compared with the Dowlais mill, which it most resembles, that it requires additional length of rolls to allow for the blank spaces or grooves. Compared with the mill "three rolls high," it offers decided advantages, and compared with the reversing rolling mill it presents the advantage of having a continuous movement in all its parts. From all the evidence brought to light by the discussion it appears that the reverssing rolling mill, without fly-wheel, and provided with a pair of horizontal cylinders reversing by the link motion, is the type of mill most in favor in our modern iron and steel works, and most likely to become the standard type of rolling mill for the future.

The question of blast furnace economy under the form of a discussion on the Siemens-Cowper stove, as modified and constructed by Messrs. Whitwell, again occupied the principal part of the time and attention of the Iron and Steel Institute. With regard to this question, Mr. Lowthian Bell has taken a prominent position before the scientific world by the extensive experimental researches of which he has recently given the results to the public, and upon which he has based the opinion that the limits of blast furnace economy derivable from the two causes, viz., capacity or height of furnace and high temperature of blast, have not only been reached, but actually exceeded in the Cleveland district, and that no material economy can be expected from further increments of these elements. This view is supported by many practical men in the Cleveland district, and in other parts of the country, while many other authorities dissent from Mr. Bell's views. The most energetic and zealous opponent of Mr. Bell's doctrines is Mr. Cochrane, who has tried to establish, by the experience of actual work, the benefits derivable by heating the blast and increasing the capacity of the furnace beyond the limits indicated by Mr. Bell. Mr. Cochrane shows, from actual experience, that he has effected a large saving in coke directly, and immediately upon increasing the temperature of the blast from 1000° to 1400°, and without changing any other condition of the work. Unfortunately for his cause, however, it appears that the furnaces upon which these experiments had been tried did not formerly work as economically as other furnaces in the Cleveland district, and that after having arrived at this relative economy Mr. Cochrane's furnaces showed about the same consumption of coke per ton of iron as the best managed furnaces in other iron works in Cleveland, which work with 1000° of blast as a maximum. Mr. Cochrane ascribes this to causes which certainly have no influence upon the question at issue, such as imperfect calcination and the general influence of alterations, new buildings, and innovations upon the economical management of materials. Another question which may still have been overlooked is the quality of the coke, which in comparing different works with each other may form an important cause of quantitative differences. So far as this discussion is concerned the question is, therefore, not solved yet, and it remains to be seen whether at some future day Mr. Cochrane, by further improving the economy of his furnaces, will force Mr. Bell to modify his theory, or if the scientific discoveries of Mr. Bell, and the practical conclusions deduced from them, will find in the future experiments of Mr. Cochrane a striking and important corroboration.

Some of the principal planters of Bom Jardim are promoting a scheme for a narrow-gauge extension of the Bahia and San Francisco Railroad, about 16 miles in length, from Alagoinhas into that district, which, if carried out, could not fail to be a valuable feeder to the railway.

THE METALLIC MINERAL RESOURCES AND PRECIOUS STONES OF RUSSIA.

From the "Mining Journal."

It is not generally known in England that the Russian empire is immensely prolific in metallic and other mineral resources; yet there are few, if any, substances known under these heads which are not found in some parts of the Czar's wide-spread dominions, which have been estimated by some as equal in extent to the great satellite which attends and cheers our world. It is not more than a century and a quarter since the Russian Government became aware of the presence of gold in the Oural and Oural Mountains, the only part of the empire then supposed to contain that precious metal. However, in less than half a century after, the people obtained in the washings in that district not only gold, but silver, copper, and some precious stones, particularly topaz; subsequently, rubies and carbuncles, so often discovered in the presence of gold, were obtained there.

The methods used to procure the gold from either the sands or the quartz were exceedingly rude, and the quantity, at first small, gradually increased up to 1820, when, with the yield of silver, the value was estimated at 20,000,000 of silver rubles (£2,500,000 sterling). Since then the increase has gone on more rapidly, new fields have been opened up, and now gold-bearing strata are found to stretch along the whole range of the Oural Mountains, from latitude 45 to 67 degs., in the northern slopes of the Altai, in the southern shoots of the same mountains, on the land near Irkoutsk, along the River Amoo, and in the Kirghis steppes.

In the Oural the gold gravel, or debritus, is not usually more than a fathom from the surface, and is often found 10 ft. thick. The gravel is covered with clay, above which is a soft peat, itself covered by the common soil.

The washings on the Amoo are seldom rich, and very large nuggets are uncommon anywhere, even in the Oural or the Kirghis steppes. It is reported that there are very extensive and rich sands in Mongolia, on the other side of the Russian territory, which the Imperial Government is anxious to possess. In Eastern Siberia the washings can only be pursued from May to September. Judges have not hesitated to proclaim that, on the whole, Russia is richer than Australia in gold. Silver is principally obtainable on the Altai, where an average of 60,000 lbs. annually is produced. It is not generally accompanied by lead there. Lead is, however, found in the Altai, and in nearly all the gold mining districts, but its discovery and working are not pursued with either spirit or intelligence, and the total yield is small. No doubt exists of large stores in all those ranges. Platinum is more eagerly sought, as the Government until lately used it in coin; for nearly half a century it has been obtained in moderate quantities in Nijni Tagil. During the last decade there has been less inquiry for it. Black lead, equal to that of the English mines, is found in large quantities in the Saian Mountains. The Oural Mountains, so productive of the most precious metal, produces nearly all the metals in quantities more or less considerable. Copper was worked time immemorial in several parts of Siberia, and in the Kirghis steppes, but nothing remains of those workings but a well-sustained tradition. Modern operations in quest of copper are little more than half a century old. The mines of Nijni Tagil and neighboring setts have acquired a great reputation. Nearly the whole eastern slope of the Oural abounds with this metal. It appears, however, that the yield of the percentage of both in ancient and modern times was very small throughout the extensive range in which the ore was found. The manufacture of copper in all parts of the empire where works exist is rapidly declining, in consequence of the fall in price of the metal and the large supplies from South America, and the inadequate supplies of wood for charcoal, the fuel employed in most of the districts where the metal is found.

The declension of iron manufacture in Russia is also obvious, chiefly from deficiency of fuel, and the great distance of the mines from the centres of commerce and civilization. The iron industry in Russia owed its origin to Peter the Great, and 150 years ago vast mines were wrought

and great works erected. The empire seems to produce every description of ore, and each in great variety.

In the Altai and the Oural vast masses of magnetic ore are found. There are various other directions where magnetic ore is found in smaller deposits. Very fine ore for the purpose of steel manufacture is extracted in several districts. Ordinary ores are much more abundant, and are discovered over a wider area of country. In the centre of Russia red oxide is the prevailing yield. One great advantage is that a deep iron mine is not known in Russia; whenever the metal is found it is near the surface. It would be impossible to estimate the resource of the country in iron; probably it exceeds that of any other country in the world.

Chrome and sulphur are also obtained there. Sulphur pyrites abound from the Northern Oural to Pensa. Tin, so much prized in England, has been found in several of "the Governments" of the empire, but is worked in none. Diamonds have been sought with much persistence, but no mines exist. In the North Oural they are not unfrequently picked up. A single emerald vein was discovered some years ago, yielding some of the finest specimens in the world, but through Government mismanagement and greed it has been lost sight of. The supply of jasper is exceedingly fine and abundant, literally mountains of it may be said to exist. The subject of the non-metallic mineral resources of Russia shall on some future occasion engage our attention, as also highly important and interesting.

COAL-BURNING LOCOMOTIVES.

From "The Engineer."

A complete treatise on the various devices which have been suggested, patented, or employed, to enable locomotive engines to burn coal instead of coke without smoke, would constitute a very bulky volume indeed. Yet the number of such devices in actual use in this country, and at this minute, is exceedingly small. Locomotive superintendents have apparently arrived at the same conclusion as many other thoughtful engineers, who accept the fact that while it is possible, under all circumstances, to burn coal without smoke, it is very frequently not worth while to resort to the appliances essentially necessary to securing this end. In plain English, it does not pay to prevent or consume smoke when the prevention or consumption can only be effected at the cost of loss of power, or by the use of complex and expensive boilers, fire-boxes, and smoke-preventing apparatus. In the neighborhood of the metropolis and large non-manufacturing towns our railway companies find it cheaper to burn a smokeless, or nearly smokeless, coal, than to resort to the use of a coal perhaps a shade less expensive, which can only be prevented from giving out clouds of smoke by great care, incessant attention on the part of the stokers, and the adoption of fire-boxes and boilers troublesome to make and costly to repair. One by one of all the so-called systems of coal burning are disappearing from our great railway lines, and the normal type of locomotive furnace of the present day is identical with that of a period when the general consumption of coal in locomotives was a thing yet undreamt of, with the addition of a brick or fire-clay arch, and a scoop deflector, supplemented by a steam blower in the chimney. The substitution of coal for coke in locomotive working dates back as far as 1837, when Gray and Chanter introduced modified grates. They were followed by Dewrance and a host of others; and it is indisputable that very smoky coal indeed has been burned without causing any great annoyance to the public, by the use of various devices more or less complex. It must be borne in mind that the first locomotives ever worked, burned coal only; but such locomotives as those of Blenkinsop, Trevithick, or Stephenson, constructed previously to the Rocket, did not convey passengers. They were worked, not before the public, but in comparatively isolated districts, where smoke was not regarded as an especial evil to be complained of; and the substitution of coke for coal may be regarded as a refinement introduced to please the tastes of a totally

different race, at a period when every item of railway expenditure was calculated on a princely scale. As soon as it was discovered that the possession of railway shares did not necessarily augment a man's income, first steps in retrenchment commenced, and costly coke gave way to coal. No engineer ever doubted that as much steam could be made with coal as with coke in a given time—though some individuals, not engineers, entertained serious doubts on the subject—and the best endeavors of inventors were therefore confined to finding out and embodying in practice those conditions under which coal could be burned without smoke; and as the manner of many inventors is, they, as a body, always used the most bituminous coal they could get. The result was that smoke was kept down with difficulty in costly boilers. It remained for the present generation of locomotive superintendents to find out that the best and cheapest remedy for smoke is to burn a coal which only makes it in moderate quantities. No heavily smoking coal has ever yet been burned in locomotive fire-boxes without causing a nuisance, or entailing more trouble than it was worth; and so we find that in all locomotives of the latest type, with a very few exceptions indeed, the old-fashioned horizontal grate and approximately cubical fire-box is used, just as though coke was to be burned, a brick arch and a scoop being the only additions to an arrangement dating back to the year 1832. We believe it would be difficult to pick out half-a-dozen locomotives in England built during the last twelve months, and excluding the South-Western Railway, in which combustion chambers, step grates, steeply inclined grates, or midfeathers can be found. Where these things exist now, they are being done away with. For example, Mr. Martley, of the London, Chatham, and Dover Railway, has greatly modified the boilers of nearly all his heavy mixed engines of the "Swallow," "Stork," etc., class. These engines had Cudworth grates of great length and steep pitch, separated by a midfeather, the boilers being, for the most part, flush. These fire-boxes have been taken off and replaced with square, or nearly square, boxes of the old coke type, the outer shells rising above the boiler barrel instead of being flush with it. The side frames have been cut so as to bring up the cross tail-plate close to the tires of the trailing wheels. The size of the foot-plate remains unaltered, but the whole engine is shortened by about 15 in. The effort, æsthetically considered, has been to convert perhaps the ugliest engines in England into very good-looking locomotives; while, as regards coal, the change has been attended by an immediate and remarkable diminution in the fuel accounts. If anything, the engines make less smoke since the alteration than they did before, even with the same coal. We find it not easy to doubt that other locomotive superintendents will follow Mr. Martley's example.

It may be taken as proved that no locomotives exist which do not give out smoke if a bituminous coal is burned on their grates. It is true that such coal can be burned in many engines without much, or perhaps any, smoke; but in practice this end is never secured. To burn bituminous coal without smoke under any circumstances requires more care and skill than can be expeeted from an ordinary stoker; and it is also essential that the engines should be moderately loaded. The great principle of all smoke-burning furnaces is to secure intimate mixture of the gases with a sufficient quantity of air; but this requires time, or space, which may be taken as equivalent terms. It may be quite possible to burn coal without smoke at the rate of 20 lbs. per ft. of grate per hour, when it would be impossible to burn double the quantity without producing dense masses of smoke; but a stoker firing an engine struggling with a heavy load will do all he can to burn as much coal as he can in a given time. The result may be seen on any North-country railway. As mitigants of smoke, the brick arch, the scoop, and the blower are as efficient as any more complex and expensive devices; and as the best result to be had in practice is apparently only a mitigation of the evil, whether the smoke-preventing devices are costly and complex, or cheap and simple, cheapness and simplicity are naturally preferred. And, after all, is the production of some smoke such a very serious evil? Where smoke in any form is intolerable, or, at all events, untolerated, it seems there are but two ways of getting rid of the nuisance. The first is to burn coke; the second to use a smokeless coal.

MODERN ARCHITECTURE IN WESTERN INDIA.

From "The Building News."

Sir Bartle E. Frere, K.C.B., G.C.S.I., delivered a lecture on this subject at the Royal Architectural Museum, Tufton street, Westminster, on Wednesday evening, the 26th ult., Sir Walter James, Bart., in the chair. After entering at some length into explanatory remarks concerning the ancient architecture of India, Budistic, Brahminical, and Mahometan, the lecturer proceeded to treat of the modern architecture of the empire. He said that when the English nation suddenly found itself the possessor of the great empire and of its great works of architecture, architecture in England was at such a low ebb that we could not realize what was essential to the progress of the art in India. It was difficult to describe the character of our early Anglo-Indian architecture; its only characteristic was extreme broadness—an utter absence of anything like distinctive features. This was only to be accounted for by the fact that we sent forth our representatives to receive and acquire the Indian empire at about the same time as we were building Red Lion square and the acres and miles of featureless streets, roads, and squares, and the nightmare churches so unlike anything which is dreamt of as a church, whether in a town or a country village. Our ancestors, in consequence, left no good architecture after them in India. An ordinary Indian station was as nearly as possible like a nightmare of umbrellas in brick and mortar. Were the materials brick and mortar, stone, or anything else, they were put together so as to afford shade and shelter, and nothing else. In Kurrachee, for example, it is impossible to conceive of anything uglier than the buildings of the place as carried out by the British officials (of whom Sir Bartle was one). In Kurrachee there are nothing but straight roofs, projecting on each side, and giving plenty of shade and shelter, mounted upon a certain amount of bricks and mortar, or timber; but of anything like architecture there was, up to the time he left the place, none, although there was a population as large as that of Bath. Perhaps it might be said: "But we have heard of a certain 'city of palaces'—Calcutta; surely there are some palaces there?" Well, although he was travelling out of Western India, he could only say that the "palaces" of Calcutta were palaces of brick and stucco, built on a foundation very much resembling that of our own good town of Sheerness; a hundred years hence, probably, the English people would not look with very great pride on the "City of Palaces," because the materials employed are not such as any architect would use for architecture of a high order or intended for posterity. In Bombay things were little if at all better. The Government House there was a Jesuit church, and whatever feature it may possess of architectural grandeur is certainly not due to the British Government. At Madras there are one or two very good buildings connected with the Government, but architecturally they are such as would be found in almost any second-rate country town in England, and their pleasing effect is due to a very beautiful variety of plaster which is afforded by the corals and shells of the coast. The whole of what the English Government has done for the adornment of the capitals of India may be summed up by saying that very few public buildings have been erected which would be considered in any seaport town in this country to be above ordinary merit. But while this is true of the Government, there is much in all the Presidency and chief towns of India of great architectural interest, due, as is the case in most parts of the world, and under all governments, to the people themselves. It has no more been in our power to impress permanently upon the architecture of India any feature of our own than it has been in the power of any government in Europe to give an architectural bias to what is built by the people over whom that government rules. Of course in a long series of ages much may be done by a government, and as we see in France, a government may, by power steadily and sternly applied during a whole generation or two, produce an amazing result on one large city; but what is likely to be the verdict of posterity when they contrast the modern architecture of Paris with the works of the great architects who preceded our own age?

There were many who would lament, even for the good results that had been achieved, the destruction of much that was interesting in old Paris ; and where were the buildings in modern Paris that could compare with the cathedrals and chateaux of France ? and will not these cathedrals and chateaux be speaking architecture to posterity when Paris has ceased to be regarded as more than immense mountains of stone ? We were very apt to decry our own city of London as inferior to the capital cities of the despotic powers of Europe, but in London was to be seen the impress of an architecture that grows from within—an architecture that expresses what the people think, and feel, and mean, and not what they are told to think, feel, or mean, as was too often the case in the despotic capitals of Europe. The lecturer then went on to describe the state of Indian civilization at the time the Empire came under British rule, and referred to the state of Bombay when Mr. R. W. Crawford (now M. P. for the city of London) was Chairman of Justices in that place. Mr. Crawford instigated great reforms. He found the city without good water to drink, without drains to carry away the refuse, and without any of the conveniences of modern civilization except a few good roads ; and he proceeded to supply the city with water, and to construct good drains, in which work he was ably seconded by the whole body of English and native Justices, and received great assistance from the Royal Engineers, Mr. George Clarke, an engineer in Bombay, and Mr. Conybeare, an architect, who erected the first church worthy of the name in India. This church, however, owes some of its best features to Mr. G. G. Scott, who was appealed to to give a design for a memorial church to those who fell in the Affghan wars. He gave a very beautiful design, but one too elaborate to be carried out for the money ; thefore another design by Mr. Conybeare was substituted. The erection of this church gave an immense impulse to the spread of good architecture in India, and much of this impulse was due to two members of the Museum, Mr. T. Roger Smith, and Mr. Trubshaw. The latter gentleman went out to Bombay at a time when there was a great influx of wealth into the city, and when many men who were in trade or business found themselves possessed of very considerable means, and the native merchants used this unexpected wealth in a manner that would have done honor to any community of Englishmen. The lecturer concluded by dwelling at some length on the public-spirited liberality of the Parsee and other native gentlemen, and on the influence which their munificence has had on the architecture of the great cities of the Empire. He referred to the labors of Mr. Parris, Mr. Morrisey, and Mr. Emerson, who had, he said, all followed in the steps of Mr. Trubshaw in endeavoring to found what he believed to be an indigenous school of Anglo-Indian architecture, as extensive and as distinct as the pure Hindu and Mahometan schools of former days ; and he believed that if God granted us grace to hold the empire of India for a few generations longer, we should leave behind us in architecture, as in other respects, such marks of our government as posterity would not soon forget.

The railway line from Moscow to Tarostavl, or Yerastavl, was opened lately from one end to the other. The Government of Tarostavl produces linen and timber. The present railway company demands the concession of a branch from Makarovo to Kustrama. Moscow is now the terminus of six great railway lines, *i. e.*, Nicholas Line to St. Petersburg, 634 kilos., N. W. (393 miles) ; line to Tarostavl, 277 kilos., N. E. (172 miles) ; line to Neejnee-Novgorod, 430 kilos., E. (267 miles) ; line to Riazan, open now to Tambof, 471 kilos., S. E. (292 miles) ; line to Kursk, and line from Kursk to the Sea of Azof, 1,327 kilos., S. (823 miles) ; line from Kursk to Kier and Odessa, 1,300 kilos., S. W. (806 miles).

M. Quenault, an indefatigable observer of the encroachments of the sea on the coast of France, writes from Montmartin-sur-Mer, to the effect that he has discovered below Hauteville-sur-Mer, near the Maulieu rock, remains of a submerged forest. These remains are covered by 12 metres of water at spring tides. The oaks only have preserved their hardness, the other woods being soft, like a paste, although they have retained their color and bark. He dates the immersion about the eighth century.

SMALL PORTABLE ENGINES.

From "The Engineer."

The Royal Agricultural Society will, we understand, give special prizes this year for the best and second best engines in a class which has hitherto hardly ever received either prizes or notice. This class embodies all the little engines with vertical boilers fixed on cast-iron bases or pedestals, which are to be counted by the score at every agricultural show in the kingdom. How they are to be tested we are unable to say exactly; but it is certain that if the consumption of fuel is to influence the decision of the judges, it is quite possible, as things stand at present, for any person possessing a little energy and knowledge of the subject, to win all the prizes that may be offered without the least difficulty. As we should infinitely prefer a good competition to a species of race in which one or two makers are first and the rest nowhere, we think it well to call the attention of our readers in general to the subject, and to bring to their minds a few of the conditions which are essential to the success of any engine competing for a prize, be it medal, or money, or honorable mention.

Out of the mining districts it is impossible to find any type of steam machinery more imperfect in every sense than the little 3 and 4-horse vertical engines, which command a large sale because they are cheap. The engines are all but invariably made to sell; and yet by a strange perversity, manufacturers—we can hardly with justice say engineers—prepare their designs without any true appreciation of the proper method of turning out cheap work. It does not follow that because an engine is cheap it must therefore be nasty; but by far the larger proportion of the little engines under notice are nasty. They are bad in design, fearfully and wonderfully made as regards workmanship, unpleasing to the eye, and certain to give dissatisfaction to any luckless wight unfortunate enough to invest his money in one, and knowing all the while what a moderately good engine of the kind should be. Now, as a matter of fact, there is no reason whatever why a vertical engine and boiler of, say, 4-horse power, should not be pretty to look at, good to go, fairly economical in the consumption of fuel, and very moderate in price notwithstanding. The first point to be considered is the general arrangement. For the most part, that type of engine in which the cylinder is inverted and the crank shaft carried by a saddle bolted to the lower end of the boiler, is preferred. In preparing the design for such an engine the first point to be considered is the boiler. If this is to be moderately economical, something more than a fire-box and uptake put into an outer shell is needed. We may either use Field's tubes, or cross tubes, or tubes springing from the side of the fire-box, and running up to the crown plate, or vertical fire tubes, or a Thompson pot boiler; but whatever type is selected, care should be taken that sediment shall not accumulate in dangerous or objectionable places. It is urged by many engineers against the Field and other boilers with hanging tubes, for example, that although in a boiler kept always at work no deposit of sediment can take place in the tubes, yet that in boilers worked during the day only, and allowed to cool at night, a very considerable crust forms on the tubes. How far this may be accurately true we shall not pretend to say; the statement is reasonable and consistent with general experience. Large cross tubes do not give enough surface, and they become furred, and cannot be cleaned; vertical fire tube boilers with short tubes are desperately uneconomical. The Messenger boiler, already illustrated in our pages, appears to be one of the best of the small boiler types with which we are acquainted; and Mr. Frazer, of Bow, is now bringing out another vertical boiler, from which, we think, he will obtain good results. In any case, the vertical fire tube boiler, the boiler with one or two cross tubes, and the boiler with fire-box and uptake only, must be beaten at Oxford. They have not the ghost of a chance, for the simple reason that nothing is more easy than to design a boiler which will excel them in every point but one, viz., cheapness.

No matter how good, by comparison, the boiler may be, it will fail to give good results at Oxford if it be worked in conjunction with a bad engine. But, after all, the principal point to be attended to

is the keeping of the cylinder hot. Who ever saw one of the little engines we speak of with a jacketed cylinder, or a cylinder enclosed in the hot air escaping to the chimney, or fitted with a superheating pipe? These things are assumed to cost a lot of money, and, are therefore left out; although we may see 2 cwt. of good cast-iron put into the saddle, where ½ cwt. would do better, and similar mistakes made by the score. It is undoubtedly true that to cast a cylinder with a jacket will cost a little more than to cast it without; but the patterns once made, it will not cost much more, and the advantage will be found enormous. We have very little doubt that jacketed cylinders will compete at Oxford with unjacketed, and woe to the latter in such a case. Besides jacketing there are one or two other devices which may be used to the same end with advantage. Why should not the feed-water be heated in the chimney? Why should not the steam be moderately superheated in the same place? Nothing, again, would be easier than so to dispose of the waste steam that it should draw a moderate quantity of heated air into a case of sheet-iron surrounding the cylinder in a way which would effectually prevent condensation in the cylinder without endangering its face or that of the slide valve. In a word, there are a thousand and one ways in which the vertical, so-called, portable engine, may be improved.

We sincerely hope that it will not be found when the tug of war comes that all the improvements have been effected by a single firm.

EXPERIMENTS ON THE RESISTANCE OF IRON AND STEEL.

By A. MOHLER.

Translated from "Polytechnisches Centralblatt."

Under this title the author publishes the results of experiments, made with the greatest care during a period of 12 years, which verify his theoretic views upon the laws of resistance of these materials. We lay before our readers the author's statement of the laws and their consequences. He says:—

The rupture of material is the consequence of repeated vibrations, none of which reach the absolute limit of resistance. The differences of the tensions which limit the vibrations are therefore proportional to the disturbance of cohesion. The absolute magnitude of the limiting strains is effective only as it diminishes the difference attendant upon increased strain, which difference causes rupture.

The tensions and compressions affecting the same fibre are considered as respectively positive and negative; so that the difference of extreme strains is equal to the greatest tension *plus* the greatest compression.

The following exhibit of the results of experiments illustrates the effect of this law of resistance. With reference to resistance to bending or tension, vibrations may occur within the following limits of safety for each (German) square inch of section.

Iron	Between	+ 160 ctr.	and	− 160 ctr.
	"	+ 300 "	"	− 0 "
	"	+ 440 "	"	+ 240 "
Axengusstahl	"	+ 280 "	"	− 280 "
	"	+ 480 "	"	0 "
	"	+ 800 "	"	+ 350 "
Ungehärtelern federgusstahl	"	+ 500 "	"	0 "
	"	+ 700 "	"	250 "
	"	+ 800 "	"	400 "
	"	+ 900 "	"	600 "

With reference to resistance to shearing:

Axengusshtahl	Between	220 ctr.	and	− 220 ctr.
	"	380 "	"	0 "

Of course the greatest fibre-strain actually applied is always less than the absolute breaking limit. The following are presented as immediate results of this law:—

Those parts of construction which act positively and negatively, as piston-rods, walking-beams and the like, must be stronger in the ratio 9:5 than those which are strained in only one direction, as beams, bridges, roof-timbers, etc.

In determining the resistance of bridges and large trusses the weight of the structure, since it forms an absolute constant minimum load, may be left out of

account, provided the sum of the effect of proper weight and load does not pass the limits of elasticity.

In the case of car-spings the vibrations are between limits whose difference is quite small compared with the maximum tension; hence the coefficient can be taken larger than in ordinary cases if the steel does not suffer an inch strain of more than 800 ctr. It often reaches 900 to 1,000 ctr.; and with good steel a further increase is possible.

Those parts of boilers which are not exposed to the fire, if of cylindrical form, are subject to but slight vibrations, which are caused by the variation of the tension of the steam. Hence a greater strain is allowable than has been generally applied; but in the parts exposed to the fire, not only the waste by burning, but also the motion of the molecules due to the varying temperature must be considered. It is not improbable that the continued movement of molecules, caused by heat, acts to destroy cohesion, just as vibrations caused by other forces act.

The effect of strain is entirely different, if it is constant and static, from the effect when it is variable and productive of vibrations. It is also important to consider whether a structure is intended to serve a purpose for a limited period, or to stand for an indefinite time. It follows that like factors of safety do not suit all constructions. In every case two factors are necessary; one, which determines the ratio of absolute breaking strength; another, which fixes the ratio to the vibration that induces rupture by indefinite repetition.

The coefficient of safety should be taken large enough in comparison with the absolute breaking strain, that it may compensate for want of homogeneity of material. For this the factor 2 is sufficient. Material requiring a larger coefficient in this respect should be rejected. The limits of elasticity have not thus far been considered, and it must be left to the judgment to determine between what limits continuous deflection is allowable. A single loading, preventing further deflection, can do no harm, if it does not approach the breaking weight. In large structures it is a general rule that the limit of elasticity should not be passed.

As a coefficient of safety for repeated vibration, 2 is in all cases sufficient, and in many cases is higher than necessary.

As a result of his experiments the author gives the following table of inch-strains for permanent structures:

For wrought-iron,
Strained in both directions.....80 ctr.;
" " one direction,
total strain.....180 ctr.
of which not more than 150 ctr. should be due the variable load. If the constant strain is less than 30 ctr. the permissible total strain must be proportionally less.

For unhammered cast-steel,
Strained in both directions.....120 ctr.
" " one direction, greatest
total strain.....330 ctr.
of which not more than 220 ctr. should be due to the passing load. The constants apply to pieces of uniform section.

Experiments with spring-steel show that car-springs should not be loaded to three-fourths of the breaking resistance, if the play of the spring is small in proportion to the entire deflection. With a constant strain of 900 ctr. a play of between 900 to 1,200 ctr. is allowed.

An important addition to the resources of spectrum analysis has been made by Zöllner's invention of a reversion spectroscope, by which extremely small changes of refrangibility, and consequently comparatively slow motions of a star or sun-flame, can be detected. It consists of a spectroscope in which, by reflection, the spectrum of a source of light can be superposed above a reversed spectrum of the same source; so that if a white flame containing sodium be viewed, there will be seen in the upper part of the field a sodium line with the blue end of the spectrum on the one side, and underneath it a sodium line with the red end of the spectrum on the same side. The two bright lines may be made to coincide exactly by an adjustment; and if any change in refrangibility takes place, the motion of the line is doubled, and is also more exactly measured, because it is referred to itself as a standard.

All the telegraphs in Egypt under direction of the Government, are worked on the Morse system.

THE FLEET OF THE FUTURE.*

By MR. J. SCOTT RUSSELL.

From "The Mechanics' Magazine."

We live in times when revolutions pass so quickly, and carry us to results so little foreseen, that it is necessary to pause from time to time and see whither the race of events is tending, and consider whether our practice and policy in the past will serve us for the future, and whether it may not be wise to modify our plans by the altered circumstances in which we live—in anticipation of this institution ten years ago—and nothing can be more striking than the progress we have made in our ideas, and the revolutions we have gone through in that short time. We were then engaged in discussing this same question, and the great topic was no less than this—whether the fleet of the future should be iron or wood—ironclad or unclad. Who now dreams of returning to wooden men-of-war, to sailing fleets, to three-deckers? And yet no less an authority than Sir Howard Douglas broke many a lance with us ten years ago in a contest about the fleets of the future. These ten years have spoken and pronounced a verdict upon the past. There are few of us left now to argue that a combustible material is the best for the construction of an incombustible fleet. As you were then sagacious enough to take a far-seeing survey of the fleet of the future, which survey I feel satisfied has powerfully aided in giving a right direction to public opinion and public action in the consideration of the fleets of the last ten years, so I think it is wise now to look round and consider what the experience of this last ten years has taught us, and to look forward and consider the nature of the future ten years, and of the new conditions under which we shall henceforth have to plan and choose and act. Great events have changed the surface of the world in the past ten years. The union of remote continents by submarine telegraphs is a great event. The canal of Suez is a great event. The ocean of India is now steadily, though slowly, flowing into the Mediterranean; the current has been ascertained to be a steady one from the Indian Sea into the Mediterranean, and so into the Atlantic. That single barrier removed enables a steamship to sail from New Orleans, from New York, with a cargo of cotton for Marseilles, to unload there, and receive a cargo of manufactured goods for India, China, or Japan, and to continue with a cargo of tea, rice, and other Oriental products from Yokohama to San Francisco, thus performing the trip of 22,000 miles, equal to the circumference of the earth, without let or hinderance. That canal is a new element in the commerce of the world, in the intercourse of nations, in the wars of nations, in the civilization of the human race. The Pacific Railway across America is another great event. It makes the Americans masters of two sea coasts, gives them the commerce of two seas, and to us it opens up a short cut round the world. What events have we to meet in the next ten years? It is not hard to tell. Ten years more will cover the bottom of every sea with lines of electric telegraph. Ten years more will see the Isthmus of Panama cut through, and the Atlantic and Pacific Oceans made one. Right through the Suez Canal, all across the Indian Ocean, straight across the Pacific, home across the Atlantic; by this new canal a large steamship will be able to circulate freely round the world. I have here a plan of the canal to which I last referred, as now sanctioned by the American Government, and largely contributed to by the United States. It is to be made through the narrow part of the Isthmus of Darien, with a beautiful harbor at each end which nature has given. It is the same length as the canal through the Isthmus of Suez, namely 160 kilometres, or 100 English miles; but there is this difference, that half of it is already made by nature. When I said ten years I took a little margin. I have so great an esteem for the capacity of the "younger English" in getting through with things when they take them in hand, that I have a notion that they will fetch over such a big cargo of Chinamen that the canal will be opened in five years. Railways are rapidly stretching across the continent of Europe. Russia is pushing on her railways east-

* Read before the Institution of Naval Architects.

ward towards the Isthmuz of Suez to the Black Sea, to the Caucasus, to the Caspian. From Austria this line will be opened in five years on to Constantinople; it cannot stop there, but must go on across the Bosphorus and right down the centre of Asia Minor to Bagdad, and then along the coast to the Indus, where it will join our Indian railways. Our European railways will be prolonged until English, French, German, Turkish, and Indian railways are all united in one continuous bond of human intercourse. China later, probably, will have railways. Africa, even, and Australia will feed the trade of their harbors by railways. Who shall predict the effect of all this going of things to and fro? It is our business here merely to see what effect all these things will have upon us, on our brethren, on our duties, on our skill, on our country, on our commerce, on our manufactures, on our ships. What, in short, will be the ships of the future? The fleets of the future will plainly have to be constructed in conformity with this work of the future; the changed circumstances of commerce and navigation will help us to decide the duties and to define the construction of this our mercantile fleet. Then the nature and the duties of our mercantile fleet, when we have considered them, will help us to decide the construction and armament of that fleet of men-of-war which has its chief duty in protecting our merchant fleets and the commerce which feeds them. First, I will examine the nature of the merchant fleets of the future. Nothing in the progress of commerce is more striking than the effect of railways upon ships. Railways and ships help each other, and railways and ships harm each other; railways tend to kill all the smaller and slower class of ship; railways help to load ships expeditiously, they supply large cargoes punctually and quickly. They favor large ships, punctual quick ships. They deprive small ships of cargoes; they do the trade of distribution inland without the help of coasting vessels. Ports are still served by ships, but inland railways serve the places that ports formerly served. Distributing is no longer done by coasters; railways have killed coasting sailing ships; they have not yet quite killed coasting steamers, nevertheless they are very formidable rivals. As railways are made and multiplied, they inevitably run a severe race against coasting steamers; they take away their passengers, and inland they take away their customers. This effect will go on increasing, and they will take away the cream of the local coasting trade all round Europe, so that what remains will not be worth having. The future commerce by ships, therefore, lies not in small ships and local trade, but in large ships and long voyages, in commerce between continents. Modern commerce flows more and more every day into large centres; modern transactions become larger and larger; what is wanted is to be done at once, punctually, in bulk out of hand; quick delivery is absolutely indispensable, and, therefore, large steamships alone can do it. Hamburgh, Havre, Marseilles, Trieste, Liverpool, Glasgow, Boston, New York, Calcutta, Yokohama, San Francisco, Melbourne, Sydney, are the centres of modern commerce and modern shipping, and the fleets of the future have, as their great duty, to do the great work of carrying the products of different countries between these great centres, and we have to fit these ships for this particular kind of work. To do the work of this enlarged changed world after 1870, we want a new merchant steam fleet. Its size must be proportioned to the length or stages of its voyages. Its power must be proportioned to the special nature of its work, and its speed is a mere matter of finance. The round voyage of the world is to be as follows:—England to Suez, 3,000 miles; England to Bombay, 6,000 miles; England to Calcutta, 7,500 miles; England to Hong Kong, 10,000 miles. Shall we turn back, that is, another 10,000 miles, or shall we go on? From Hong Kong to Yokohama is 1,500 miles; Hong Kong to San Francisco 6,000 miles; Hong Kong to the Isthmus of Darien, 8,500 miles; from Hong Kong home, 12,500 miles. Thus a voyage of 22,500 nautical miles is the round voyage of the future. Now, I venture to say that the smallest merchant ship for this work is a ship of 3,000 tons nominal. According to the structure of this vessel we can make her with a displacement of 5,000 or 6,000 tons, and we can give her an easy bulk for merchandise of 6,000 tons. I think she could be driven 10 knots an hour with 300-horse power. I give this as our smallest Oriental trader. Let me

next inform you that such a vessel can comfortably go through the canal of Suez on a low draught of water. I have talked the matter over with M. Lesseps, and he assures me that the vessel I am speaking of will easily and comfortably, as long as he lives, cut through the canal. He also assures me that he has no anxiety whatever as to the canal gradually filling up. Foreseeing the difficulty, the slope was made extremely small; but they have taken the precaution of keeping no fewer than 12 of their magnificent dredging machines in stock in case of any such difficulty arising. Now, with regard to the engines and the fuel of these ships, I think that 300-horse power of our modern engines would propel a vessel such as I have mentioned, without over-working, 10 knots an hour; but I would suggest a great reserve power. We now, I think, make our engines and boilers too small; we work them to the extent of their power, and we cannot make head against a contrary wind, in which case a steamship is in more danger than a sailing vessel. If you take a larger engine and a larger boiler than you want you will require a little more outlay at first, but you will get a more economical mode of working, and you have the advantage of a great reserve behind. Then with very good engines and boilers, according to our modern plans, the vessel will consume a ton of coal an hour—that is, a ton for 10 knots. A voyage of 6,000 miles would require 500 tons of coal. The engines and boiler cannot weigh less than 300 tons. The voyage of 7,500 will require 750 tons; and the voyage of 10,000 miles 1,000 tons. Let me here mention that at Yokohama we are in the coal region, and in the course of the next 10 years you will be able to coal all your ships there; that will be our half-way house. For the 1,500 miles trip 150 tons of coal will be required; for the trip to San Francisco, 6,000 miles, 600 tons; to the Isthmus of Darien, 8,500 miles, 850 tons; and for the trip home, 12,500 miles, 1,250 tons. In the voyage to Bombay and home the ship will carry 1,500 tons dead weight of engines and coals, and have room for 2,400 tons of cargo. For Calcutta and home she will carry 2,900 tons dead weight, and have room for 2,100 tons of cargo. For Hong Kong, 3,400 tons dead weight, and only 1,600 tons cargo. But she will have this advantage—that on the home voyage, for the 6,000 miles voyage, she will have only 900 tons dead weight, and will have room for 3,000 tons of cargo; for the 7,000 miles home voyage, 1,000 tons dead weight, and room for 2,850 tons cargo; and for the 10,000 miles, 2,400 tons dead weight, and room for 2,600 tons cargo. Calculating the expense, etc., of the ship, I arrive at the following conclusions:—1. That this is the minimum ship and the minimum power; 2. That she can go and return comfortably through the canal of Suez; 3. that she can bring home and take out cargoes at existing freights, and leave a very good margin. Next we have to consider what sort of ship is wanted for a ship of war, to protect this class of merchant ships. It is perfectly plain that our future ship of war must go through the canal of Suez, and she must, therefore, draw not more than 25 ft. of water. The canal will admit, as a matter of possibility, vessels of that draught, but not as a matter of convenience, and I do not think that one ship of war should draw more than 22 ft. In the next place, I think you will agree with me that the ships of war that are to attend and protect our merchant fleet must be of a larger size, and they must be very much larger for two reasons. They must carry coal for a long voyage, and to be of any value they must go with great speed. They must carry coal for a longer voyage than the ships they accompany, and they must go much faster. The next point in the construction of our new fleet of war ships is this: are they to be built for the purpose of guarding our merchant fleet, or for the purpose of attacking land batteries? The ships that we have now constructed are perfectly capable of attacking land batteries. Iron-plated ships are absolutely necessary for that purpose, and those of the present construction amply suffice. But to accompany and protect the new fleet of the future we must have quite another class of steamships. First, it must be a ship from 5,000 to 7,000 tons nominal; secondly, it must go certainly 15 knots an hour; thirdly, it must be much more manageable and quick in its movements than even the most manageable and quick of those that we have now got. I have taken the opportunity of conversing with all the admirals who are

most likely and able to command the fleets to attack us, and I have gone with them thoroughly into this question. I have also had the privilege of conversing with the most distinguished officers who are likely to command our fleets. I will give you the conclusion, which many of them will refuse to admit in public, but which I think it is the interest of the British nation thoroughly to know and deeply to weigh. It is agreed by the most able sailors I know that the one weapon to fight with is stem on. Though he will deny it, and say he will not do it, the one intention of every man who is likely to command a fleet is to give the enemy his stem on, and run him down at all risks. May I say that the weapons constructed for this fence are not the weapons best suited for this practical purpose? I, therefore, earnestly call upon all naval constructors here present to give their minds with the most untiring devotion to the one fence of running down. You will see that other nations have thought of that, and made their preparations for it to a far greater extent than we are doing, or possibly have any notion of doing. Now that leads us to the next question—what guns shall these ships have? and what protection shall the ships have? I think it is not necessary that they should have protected batteries of guns. It is indispensable that the engines, the boilers, the magazines, and all the essential elements of the ship, should be thoroughly protected; but I do not think that the gun-deck of such ships requires any but a small protection, because with this new fence the battle of the sea is over in a very few minutes. Consider what a naval engagement must be between two such ships. I see my enemy coming towards me; I either run away, or I do not, or I go forward; if I run away the less that is said about that the better; if I lie still there will be nothing to say, therefore I go to meet my enemy. When we meet, what is the great point between us? Which shall give the other the stem. It is not a question of how many shots I shall fire out of a round turret. When we get close to one another one of us succeeds in running into the other; if not, we both sheer off, and then is the time, and only for a moment, when the guns are wanted—not one, or two, or three guns, fired at a long range, but a broadside of the greatest number of guns you can have ready loaded to discharge as you turn. What you want is a broadside of the largest guns you can place on board the ship, thoroughly unprotected, with competent gunners, who, I may say, do not care two straws for the protection you are offering them. That broadside must be discharged in a moment, and the larger mass of shot you can, at that critical instant, pour into your enemy, the better. Then you go away, turn round, and come back again. That is the mode in which a battle must now be fought out. Am I wrong in saying that such a battle requires a totally different weapon from any that we have hitherto had?

THE BOUTET BALANÇOIRE.

From "Engineering."

We notice that Charles Boutet has, not a little to the discredit of the Patent Office, obtained protection for his bridge; there really ought to be exercised sufficient supervision to prevent such so-called inventions from being sanctioned, as they are, to a certain extent, by the stamp of the Great Seal. Thus, notorious Pidding knows well that whenever he obtains provisional protection for some nonsense, he can always find a certain number, who are to be led into the belief that a patent is equivalent to a "Royal Charter"—words of vague but portentous meaning to the ignorant. Whether Mr. Boutet seeks further to establish himself by the help of his patent, we know not; possibly a pressure has been brought to bear upon him similar to that recently developed in the case of the Fenian leaders, whose followers insisted upon smelling powder or getting their money returned. This is, however, beside the question. Mr. Boutet is laboring hard at the cause he has taken up, and the publication of his patent and its accompanying drawings gives us an insight, we presume, into his latest designs. That these are thoroughly in keeping with all that

the patentee has hitherto done is to be expected, and we take it for granted that the drawings illustrate the method on which the 100-metre model of which more or less has been said, and that is a facsimile of the great 3,280-ft. channel spans, has been constructed. There are six distinct features in the patent: the cable lattice, the piers and mode of sinking them, the means of straightening the cables, the means for twisting the cables, and the hand-rail upon which the stability of the bridge depends. In addition, there is shown and described an arrangement for deep-sea levelling—a plan for ground and bottom fishing Mr. Boutet should submit to the consideration of submarine telegraph engineers.

Mr. Boutet shows a drawing of a bridge of which the abutments are 108 ft. high, and the span some 180 ft., although, as this latter is broken in the centre, and as length of span is a matter of no moment, we may presume it represents a bay, say, 3,280 ft. long. Upon each of these abutments is placed a bed-plate with bearings for the cables to lie in, and an adjusting arrangement consisting of a slide resting in a cast-iron frame, and carrying, by means of brackets, a bar, upon which the ends of the cables are looped. A series of screws are added by which the slides can be set up, and the cable straightened. The cables are shown about 9 in. in diameter, and are stretched from abutment to abutment, parallel to each other, and about 2 ft. apart in a horizontal row, smaller cables being introduced transversely at certain intervals to bind the others together. This web is then sandwiched between two rows of planking, the upper one being made of oak, the lower one of deal, and the network is thus "held firmly between the two plank surfaces or floors." Transverse beams (they are called longitudinal in the specification) are placed at regular distances, and to them are fixed the hand railings, which not only "serve as railings to fence or protect the passengers, but also add to the vertical rigidity of the structure." N. B.—The patent drawings show this hand-rail some 23 ft. in height. In long spans the inventor reduces the area of his cables by making them in short lengths, and linking them to transverse bars, the number and size of the cables decreasing towards the centre from the abutments. In order to straighten the cables—for it must not be forgotten that Mr. Boutet maintains that he does make them quite horizontal and even cambered—a primitive device of a train of levers is patented, and a common arrangement for twisting the wires is also shown.

This wonderful bridge consists, then, of a platform made of a number of ropes stretched horizontally (which is impossible), and laid parallel to each other woven with cross cables, and held at the abutments as described. It is, in fact, nothing but the old rope bridge used in the East any time these last 3,000 years, secured between two points—and stretched to breaking. In all justice, however, to Mr. Boutet, it must not be forgotten that we are describing only the invention as noticed in the specification; he *may* have, of course, something entirely different, and which deserves the eulogies bestowed upon it. But we have only to do with the matter before us, and are bound in the meantime to conclude that the invention is fully and completely set forth in the patent. According to the description, Mr. Boutet evidently relies upon his timbering and hand-rail for the stiffness of his structure, and this could, of course, be effected in the small models; while in the 100 metre span they would be equally utilized. But it is scarcely necessary to point out the utter absurdity of such an arrangement in the extravagant spans Boutet speaks of.

The introduction of the cables is, indeed, worse than useless, and the less we hear about them the better. And here we must again call attention to the fact that only recently a journal of high standing and influence has drawn public attention to the Boutet bridge as a marvel of strength and engineering skill; a panegyric the "Scientific Review" has endorsed by reproduction. In that notice Mr. Page's remarks, delivered in the course of a paper read not long ago at the Society of Arts, have been wofully misunderstood. When will periodicals, whose duty it is to guide, cease to impede the real cause of progress by injudicious advocacy?

A new cylindical iron railway carriage has been patented by Mr. N. Maccartney, of Glasgow.

THE STRENGTH OF BOILER PLATES.

From "The Engineer"

We are not about to speak of any of the fantastical theories once advanced to explain boiler explosions; we shall deal with a single question, believing that our readers will find quite sufficient food for thought in its consideration to last them for some time to come. This question is, do boiler plates become brittle in use, or do they not? In other words, does a plate in a boiler gradually deteriorate in quality, or does it not? Whether a rail deteriorates or not, is a question which has been hotly disputed, but, until very recently, no one thought of assuming that a boiler plate, externally sound and free from corrosion or marks of overheating, could be otherwise than as good as when it was worked up by the plater. It just begins to dawn on the members of our profession that it is possible that a plate may undergo molecular change of some kind during twenty years or so of work, and this once proved, a most important addition will have been made to our knowledge. We have no doubt whatever that boiler plates do, under certain circumstances, undergo a rapid degradation of character, resulting in absolute untrustworthiness or ultimate failure. It is not difficult to adduce evidence in favor of this belief, or a theory to explain it; we shall give both; not that either fact or theory is in any sense conclusive, but because both are suggestive, and may—we trust will—lead to further inquiry—the foundation of all knowledge.

In a recent impression* we described the results of certain experiments conducted by Mr. Carmichael, to determine the strength of boiler plates many years in use. We, at the time, made a request, which we now repeat, namely, that whenever an old boiler is broken up steps shall be taken previously to test its absolute strength; and the results placed on record in our pages or otherwise made public. One gentleman of large experience has courteously responded to our invitation, and sent us particulars of some tests of certain boiler plates which had been fractured in an explosion, it is unnecessary to say where. The strips were cut out where they could be got. Nos. 1 and 2 were old plates; No. 3 had been a repair plate:—

No.	Area of section.	Broke with tons.	Breaking strain per sq. in. area.	Stretch.	Contraction at fractured part.
1	.4556	9 5–20	20 6–20	5 per cent.	6 per cent.
2	.4690	8 5–20	17 11–20	4 "	4 "
3	.4824	10 5–20	21 4–20	5 "	5 "

The boiler was one of the egg-ended cylindrical type, plated longitudinally, and had been in use about fourteen years. The pieces Nos. 1 and 2 were hard, and fractured soon after they left the line of the plate; No. 3 stood a fair test. "These," writes our informant, "are deserving of attention, as showing that a brittle or hard plate may give a good result to a direct strain."

The next results are from a rent plate from the boiler at Bingley, which exploded in June last; the strips were each way of the grain, and gave exactly the same results:

No.	Area of section.	Broke with tons.	Breaking strain per sq. in. area.	Stretch.	Contraction at fractured part.
4	.5289	11 10–20	21 14–20	3 per cent.	5 per cent.
5	.5289	11 10–20	21 14–20	3 "	5 "

These were subjected to other tests, as follows:—A, strip hot, bent inside of the plate outside, the ends were brought together, and there was found to be a small crack across the bend; B, a strip hot, outside of plate, outside of bend—wide frac-

* "The Engineer" for April 22d.

ture; C, strip cold, broken from inside; D, strip cold, broken from outside; E, F, G, broken across the grain, with the grain and diagonally—broken cold. The results of C, D, E, F, G, were similar, showing that the outside of the plate was deteriorated and crystallized, but that the inside was fibrous and of fair quality; H, strip of plate, set cold from the outside—a slight crack was found at the angle of 4 deg.; J, strip set cold from the inside to the angle of 13 deg., at which a slight crack was found. The letters refer to the labels on the specimens. This plate was taken from the shell, and was said to be an original plate, having been in the boiler for twelve years.

Now, it is to the last degree unlikely that any boiler maker, with the least regard for his reputation, would use a plate so brittle that it stretched but 3 per cent., when we bear in mind that a good boiler plate will stretch from 7 per cent. to 14 per cent., and even more. It is a legitimate deduction, we think, from the foregoing figures, that the plates deteriorated in quality during service. It remains to be seen how such deterioration was brought about; and this leads straight up to a theory—or, more strictly speaking, the sketch of a theory—which we have already referred to.

Many able engineers hold that no deterioration whatever—always excepting corrosion—can take place in a bar or plate of iron, unless it is taxed above its limit of elasticity. Whether this is or is not true of plates, bars, or rails, at normal temperatures, we shall not stop to inquire. It is not true, in our opinion, of boiler plates, or of any other forms of iron exposed to considerable degrees of heat. M. Tresca has shown very conclusively that iron will "flow," even in the apparently solid state, in a way precisely similar to ice in a glacier, or the lead "squirted" into bullet bars under hydraulic pressure; all that is necessary is time and power. It may be safely assumed that there is no substance in nature which can not be made to "flow." In other words, that an absolutely rigid solid, a something the molecules of which do not and cannot change their position with regard to themselves and extraneous objects, has no existence save in theory. It is also certain that heat operates powerfully in promoting the flow of solids. Who will maintain, then, that the molecules making up the plates of a boiler, said plates being exposed to a temperature on one side of perhaps 200 deg., while the other is in contact with water at, say, 220 deg. or 280 deg., will not change places and assume new relations towards each other under the influence of heat, strain, and motion combined? We say motion, for it must be borne in mind that every boiler is continually changing its shape from hour to hour, or even minute to minute, as the pressure and temperature vary. To fancy that these influences—heat, strain, and motion—can continue to operate for years without bringing about some change in the structure of a boiler plate, is to assume that the molecules possess a degree of immobility which they do not possess. If we apply a heavy strain to a piece of plate we can upset all relations previously existing between its component particles; the plate contracts and becomes hard. Have we the least ground for assuming that under a less strain no change will take place? Experiment clearly proves the contrary, and we need not dispute the point. In the very experiments we have recorded it appears that the outside of a plate exposed to a high temperature becomes crystalline, while the inside remains fibrous and sound.

Our theory is, then, that all boiler plates undergo a change in quality by the lapse of time, and under the influence of heat, strain and motion; that such a change leads up to explosions; and that the engineering community knows nothing with certainty about this deterioration, and this is the higher ignorance of which we have spoken. It is simply a coincidence, an accident of nature, which we cannot explain, that this change should result in tough iron becoming brittle and untrustworthy, instead of sound and tough. We by no means pretend that this deterioration is the invariable cause of boiler explosions; but it no doubt conduces to their occurrence, and certainly increases the destruction of life and property. A tough boiler will open and leak, when a brittle boiler will fly to atoms; and in this brittleness, no doubt, is to be found the primary and efficient cause of the ruin which attends the failure of an old boiler. It remains to those interested to investigate this theory, and endeavor, by practical tests, to ascertain whether there is or is not some law or laws in obedience

to which the work of deterioration proceeds; whether, and to what extent, if any, different makes of iron suffer more or less deterioration; and how many years of fair service should be regarded as enough to secure the superannuation of a boiler, even though it may appear to be perfectly sound.

DESCRIPTION OF THE ROCK-SALT MINES AND SALT MANUFACTURE IN CHESHIRE.

From "The Mining Journal."

Rock-salt is said to have been first discovered in Cheshire in the year 1670, in boring for coal; but the manufacture of salt from brine springs appears to have been carried on some centuries previous to this. The Trias and Permian formations have been described as follows—under the Lias—in Cheshire and Lancashire:

1.—Keuper marls of Cheshire.
2.—Upper New Red Sandstone, or bunter.
3.—Permian—red and blue marls, with limestone.
4.—Permian—Lower New Red Sandstone.
5.—Coal measures.

The rock-salt in Cheshire occurs in the Keuper marls; these are stated to be 200 yards in depth, but the total depth is probably much more than this. There are seven salt mines at present in operation in the neighborhood of Northwich, named in the order of quantity of rock-salt raised, as follows:

Name.	Proprietors.
1.—Marston Hall	Mr. W. Hayes.
2.—Platts Hill	Mr. Thompson.
3.— "	Mr. W. Stubbs.
4.— "	Mr. Judson.
5.— "	Mr. Williamson.
6.—Old Marston	Messrs. Fletcher and Rigby.
7.— "	Messrs. Thompson and Jackson.

Besides these there are 7 or 8 other salt mines suspended. The area of rock-salt that has been proved in this district is considered to be about 4 sq. miles. It does not vary much in depth, being generally found at 108 yards, from the surface to the bottom of the rock-salt.

The Marston Hall Mine produces upwards of 40,000 tons of rock-salt yearly; this is about one-half the total quantity worked near Northwich. The mine is leased from Lord de Tabley. The lease of mineral was originally within a radius of 7 chains from the pit, and 15 acres in area; this has been increased, the area now amounting to 50 Cheshire acres. The mine has been in operation 20 years. There are two pits at Marston Hall, about 12 yards apart, sunk through the salt beds; the depth is 105 yards to the floor of the bed that is worked. This bed is 14 ft. thick, of nearly pure salt.

STRATA PASSED THROUGH IN THE PITS AT MARSTON HALL.

	yd.	ft.	in.
1.—Brown clay	3	2	0
2.—Brown soft marl	3	2	0
3.—Brown friable earth, beds of blue marl, and gypsum	38	0	0
4.—Inferior rock-salt, not worked	30 yd. 0 ft. 0 in.		
5.—Brown metal, or marl stone	5	0	0
6.—Blue metal, or marl stone	5	0	0
7.—Inferior rock-salt, not worked	15	0	0
8.—Bed of clean rock-salt worked	4	2	0 = 59 2 0
9.—Inferior rock-salt	2	2	0
10.—Hard brown clay			
Total	105	0	0

The earth at No. 3 is not a marl; vegetation will not grow in it—where found, it is an indication of the existence of rock-salt below. Beds Nos. 4, 7, and 9, are not worked; the rock-salt is intermixed with blue and brown marl. The rock-salt working is generally confined to No. 8 bed. The bed of clay, No. 10, has been sunk into 60 yards in the locality, but not through it, so that the extent of the saliferous beds cannot be said to be fully ascertained until the upper New Red Sandstone is reached.

The shafts for the first 40 yards are secured with timber, and are made 4 ft. sq.; below that, 30 yards of cast-iron cylinders are inserted; these are of 3½ ft. internal diameter; they were placed after the shafts had been completely sunk; each cylinder is 9 ft. high, the full circle of the shaft; they are bolted and wedged at the joints, and filled behind with cement. By this means the springs usually found at the top of the rock-salt are completely excluded, and the mine is perfectly dry.

On descending into the mine the extent and height of the excavation, and the remarkable strength of the rock-salt roof, are the most striking points to a stranger. The bed worked—No. 8 in the section—is generally 14 ft. thick, it is got in two divisions, the top part, 5½ ft. thick, is first got; then the lower part, 8½ ft., is got a few yards behind; these are worked in a continuous face, with pillars intervening at proper distances. Pillars are left 10 yards by 8, with spaces of 30 yards between them, each way. About $\frac{1}{7}$ of the whole is thus left in pillars; as the working faces extend further from the shafts a larger proportion is left in pillars. Powder is used largely for blasting, about 1 cwt. is consumed daily. The roads at the working face are laid 10 to 12 yards apart, 3 ft. gauge; the same buckets are used on these roads as in the shafts; they are placed on a wooden frame; the frame is fastened below the axles; flanged wheels run on iron bars as rails; sixty persons are employed underground, from 7 A. M. until 4 or 5 P. M. About 20 acres of the 14-ft. bed have been extracted. No timber or other support than the pillars is required. The bed has a slight fall to the east. About 3 ft. of the floor and the same thickness of the roof is being got in 2 or 3 places, but the rock-salt is intermixed so much with marl as to be not worth working for general purposes at the present day. The mine is quite dry; great care is taken to exclude water from the works, otherwise it might be better to let them fill up with water, and pump brine from them for the manufacture of white salt. The rock-salt, as worked, contains by analysis 97 per cent. of chloride of sodium (common salt) and 3 per cent. of other ingredients. Its color varies from nearly white to dark brown. Natural ventilation is depended on in winter; in summer some artificial means is needed to clear the mine of smoke.

The winding-engine at Marston Hall is a 21-in. beam-engine, 4½-ft. stroke, two flat-rope drums, 5 ft. in diameter on second motion. Two Lancashire boilers, 25 lbs. steam pressure. One rope works to each shaft in front of the engine. Hemp ropes only are used, and one will wear two years; wire-rope would not be at all durable here, owing to the well-known action of salt and water on iron. The same engine pumps surface water occasionally, and drives a circular saw. Recently ingenious machinery has been erected for grinding rock-salt; this is effected by a 16-in. horizontal engine, 3 ft. stroke. The rock-salt is first broken by one of Blake's crushers, from this the material is carried horizontally some distance by an Archimedean screw; it is then raised by a bucket elevator, from whence it descends to the grinding rolls. From the rolls the crushed rock is taken horizontally by a screw to the foot of another elevator, by which it is raised to the vibrating riddle; the rock-salt by this is separated into two sorts, rough and fine. The rough is used in the manufacture of copper and in alkali works; the fine, resembling sand, is used for agricultural purposes. A large proportion of rock-salt is sent away in lumps, a better price being obtained for large selected pieces. This is exported extensively to Holland and Belgium, and there manufactured. No white salt is admitted into these countries.

At a short distance from the drawing shafts a shaft is sunk to the rock-salt to the depth of 40 yards. A small engine is erected to pump brine from it by a connecting rod and T-bob and 6-in pump; the pump is close-topped, and by that means the brine is elevated a sufficient height to run to a large cistern, from whence the brine is run to the evaporating pans as required. There are three pans in operation, 60 by 30 ft. each, for the manufacture of white salt; each pan is heated by four fires. The Marston Hall Works are situated near to the Trent and Mersey or Grand Trunk Canal. There is a branch railway of 1½ miles to join the Cheshire Midland Railway at Northwich.

Another branch of the works, also belonging to Mr. Hayes, is at Anderton, one mile distant from the mine. There are 16 evaporating pans here, 60 ft. by 30 ft. The works are devoted solely to the manufacture of white salt, from the saline springs, pumped from two shafts in the immediate neighborhood. The Anderton brine is understood to be fully saturated; it contains 10 times as much salt as seawater. One gallon of brine yields about 42 oz. of common salt. The analysis of this salt gives 92 per cent. of chloride of sodium and 8 per cent. of water. The production of white salt is about 30,000 tons per year. Other two companies—the British Salt Company and Darcey and Gibson

—have works adjoining to Mr. Hayes, the produce from each of which is about the same as that named. For making stoved or fine butter salt, the brine is heated to the boiling point; this is 226 deg. For common rough salt about 160 deg. of heat is applied. For large-grained crystalline salt, for fisheries, the brine is heated from 100 to 110 deg; no agitation is then produced, and the salt forms naturally in large cubical crystals. There are two shafts about 20 yards apart, sunk to the brine springs near the works above referred to; they are 75 yards in depth, to the top of the rock-salt. A pumping engine is erected at the top of each shaft. Each is a 24-in. beam engine, on second motion. From the second shaft motion is communicated by means of two cranks and connecting rods to two beams fixed on the front wall of the house; to the outer ends of these beams the pump rods are attached. There are two pumps to each engine, being 8½ in. close-topped bucket lifts. The four pumps supply three reservoirs, one appropriated to each work, from whence the brine runs to the evaporating pans. The brine springs are always found at the top of the rock-salt; the pumping operations occasion a great subsidence of the ground, over a much larger area than has been ascribed to the deposit of rock-salt. With every addition of fresh water derived from the surface more salt is dissolved, and thus a continual extraction and undermining is going on, consequent on the pumping. Nearly every house in Northwich may be said to be damaged by undermining, though there is no brine pumped in the immediate locality.

The produce of the Anderton Works is sent away, either by the Trent and Mersey Canal or by the River Weaver, which is navigable to Winsford, 7 miles from Anderton. There are five other works near Anderton where salt is made from the saline springs raised in their neighborhood, besides eight near Marston, and seven near Northwich, and several at Winsford also manufacture salt from the springs. Notwithstanding the constant demand for this prime necessary of life, and the fresh uses to which it is applied, as in the manufacture of copper, and for agricultural and other purposes, the trade is not in a flourishing state; the production more than keeps pace with the demand, and the produce from other districts has come into competition in the markets where Cheshire salt has been exclusively used. Rock-salt is now sent from Belfast by sea to supply the Newcastle and Glasgow chemical works; this has, to some extent, reduced the working of the Northwich mines.

Salt is manufactured from brine in the neighborhood of Droitwich, in Worcestershire; this has for a long period supplied a certain district with salt. Staffordshire also produced salt some years ago, from brine springs, but the manufacture, we understand, has ceased.

DRINKING FOUNTAINS AND PURE SPRING WATER.

From "The Builder."

It is a curious thing to note how the great powers that be sometimes go about things. There are two important questions at this moment before the British Parliament, of most momentous import to the whole British public: one is, that the said public shall be from henceforth compulsorily educated; and the other is, that intoxicating liquors generally should either cease to be drunk altogether, or, at least, the sale of them confined to very fashionable localities; and, to help to wean the poor helpless public from the temptations of alcoholic liquors, a society some time since sprang into existence, and a series of fountains, as they are termed, have been put up by it in all the poorer districts of London, for the purpose of supplying people with what the Drinking Fountain Society call "pure and wholesome water." Now, it is a curious fact, that all the fountains are carefully boarded up and the water-supply from them made to cease during the whole of the *winter* months and cold weather; indeed, just at the time when the sale of spirituous liquors is at its maximum, "to keep the cold out." Why is this? Surely the public, the lower orders, must drink in the cold weather as well as in the hot; and the temptations to go astray are quite as

great, if not greater, in the cold of winter as in the heat of summer. But so it is, and undoubtedly it is all right and proper; but as the season has just commenced when all these boarded-up fountains are uncovered, and the water from them allowed to flow again (at least by day, for we have found them shut up through the night, even in summer), it seems worth while to say a few words about these drinking-fountains, on the fountains themselves *architecturally*, and on the sort and amount of water which they supply. For this purpose we would call attention to the recent elaborate and instructive Report, with an appendix, on the subject of the London water supply; it would seem to call for some notice beyond what it is likely to meet with at the hands of those who look on it only as a sanitary matter. We are what is called a practical people, so that in the event of any change for the better taking place, either in the kind of water supplied to Londoners, or in the mode of its supply, we may be quite sure that *art* will come in but for very meagre notice, if for any at all. A few words, therefore, may not come amiss about it before anything is finally determined on. To begin at the beginning. *Rain*, says the "Report," is the source from which all water-supply is obtained, and there are *three* modes by which the water thus provided by nature is made available for the supply of towns. We ask attention to them. The *first* is to bore down into the porous strata, and thus to come directly to the purest of all water, that which springs up into wells, and which sometimes reaches the surface and bubbles up as springs. *Secondly*, that which is obtained from rivers, and which is the natural drainage of a country. The Thames thus drains not less than 6,000 square miles of land, *i.e.*, the rainfall over this area falls into the river-bed. The *third* mode is by forming large reservoirs in hilly districts, and then to collect and store up in them the rain or surface water, this being conveyed by pipes to where it is wanted. Be it observed, that none of these methods insures the collection of *pure* rain-water, the water being necessarily mixed with earthy and mineral matter by the fact of its passing through or over the ground on which it falls. It seems, therefore, a pity, as we have before urged, that some plan has not been devised for collecting pure rain-water from the tops of houses into tanks or cisterns. This would be a fourth mode of water-collecting. Rain, it is said, is the very purest and softest of all waters, it being the result originally of simple evaporation. If a glassful of Thames water be simply allowed to settle so as to become clear by the mud falling to the bottom of the glass, this water on being tasted will be found to be *soft* and almost like June rain-water. Or, should any one be bold enough and hardy enough to *bathe* in the river, he will find the water delightfully soft and *pure*—pure barring the mud. If, then, after these two simple but bold experiments, the same person will dive into a common plunge-bath, and venture to taste the water from one of the common drinking "fountains," as they are so poetically called, he will discover that though the water be said to come from the same source—the Thames, the bath water will feel like pounded ice, and as hard; and the taste from the "fountain" like unto some diabolical semi-warm mixture of he knows not what; as hard as cast-iron and about as palatable! What, therefore, we would ask, do the water companies do with the water? Why not leave it alone, and allow the pure river water, after depositing its mud to find its way into baths and fountains in its *natural* state?

But, it may be asked, why take the "river" water, with all its impurities, about which there is so much in this Report, all the great scientific authorities contradicting each other about it, no two of them seeming to agree? Now, it so happens, says the Report, that no less than two-thirds of the Thames basin consist of porous and permeable strata, such as chalk, oolitic limestone, and sand and sandstones of various kinds, all of which receive and absorb a large proportion of the rainfall, and store it up in vast subterranean reservoirs, forming well and spring water, water made pure and palatable by great natural processes, costing nothing but the getting at it, by the sinking of wells and pump-pipes. This grand natural process reduces organic matters to a minimum, and mineral matters to the smallest amount; is independent of the seasons; gives uniform temperature, and the filtering process as perfect as can be; for, as the "sections" show, from 50 ft. to

300 ft. thick of sand, or limestone, or chalk, are gone through. It is something wonderful what an amount of evil is put up with by the poor British public. There is all this exhaustless supply of the purest and best of water under our very feet, and needing only the most common of mechanical appliances to come at; yet it is never even thought about, while the substance called water in common use is really unfit for any purpose whatever, either for washing or drinking.

But there is another aspect of this important subject which will, if not at present, at some future day meet with the attention which it is worth. If we travel into countries and towns uncivilized and *barbarous* enough, such as Constantinople, or Damascus, or even Utah, on the Salt Lake, it will be found that not only is there a plentiful—nay, magnificently liberal supply of the purest and most delicious of water—but no pains and expense have been spared to render this supply not only complete, but pleasant to the eyesight. The reader will see nothing of this in the Report. London and Constantinople or Damascus are wide enough apart; but in the last-named cities *the water is alike utilized and made beautiful.* Instead of the little dribbling, sickly streams which flow from our drinking fountains, and which take their time to fill a wineglass, and which in most cases spout out of a foot or two of paving-stone into a shallow basin, the size of a common dinner-plate, the real fountains to be found in those far-off and barbarous cities are really works of art, to be seen a mile off, with water enough to be at least seen and heard as it falls; a something to pause to look at, and a happiness to see. A photograph of a beautiful fountain worthy of the name, near the "Sweet Waters" of Asia, and quite a gem of Moslem architecture, may be seen in Gautier's Constantinople, together with another—but far too big and luxurious for our shopkeeping nations—that of the fountain of the Sultan Selim. Constantinople, be it observed, is a barbarous and almost heathen place, and a remnant of old and fast-failing times and ways of work, and unhappily modern improvement will consist, when it thoroughly seizes hold of this place, in doing away with all these quaint "water supplies," and substituting "taps" everywhere. Let the intelligent artist reader balance the loss and gain mentally and bodily. London improvements would seem now to consist mainly in pulling down as many houses as possible, and forming large, awkward, open waste spaces; would it not, we would ask, be a good plan to occupy some of these with drinking fountains worthy, at least, of the name, with the water supplied from the lower strata, as explained in the Report,—*i. e.*, with well or spring water, of which there is such an inexhaustible supply. Such water is always pure, drinkable, and of even temperature, and constant in quantity. In these fountains the *water* for which they are constructed should show itself visibly—*i. e.*, it should be seen that the fountain was made for the water, and not the water for the fountain;—large open basins and a perpetually running stream. It would be difficult to devise a plan more likely to be acceptable to the public, especially the poorer and out-door public. It would be easy to name some score of open spaces where "fountains" such as we have indicated would be useful and desirable. Nothing can be worse than the now so fashionable mode of improving London. Everything is destroyed, and there is nothing in idea to replace the old plan of streets, bad as they are thought to have been, or are. We may, before it is too late, learn something from Constantinople and other of those distant and really wonderful places, truly called cities, built and planned so long before science and "art principles" had any existence, but yet at a time and by a race of men whose ways we may well try to recall and humbly imitate and follow. There is, surely, a long distance between a Turk and an Englishman; and if the Sultan and his subjects are to be civilized by the adoption of English ways, let us borrow something from them before it is lost for ever.

One other thing there is in this water-supply question which ought not to pass without notice, as it is not a little curious, and shows the universality of the great laws of nature. Everybody has heard of the impurity of London river-water, one way or another; but the Report says, that taking properly-filtered samples of Thames water, we shall see an "extraordinary regularity in the albuminoid character of good

town waters during summer months." Thus it would appear, that Thames water, Manchester water, Edinburgh water, and Glasgow water from Loch Katrine, show in a most remarkable way the great constancy in the amount of such impurities as *ammonia*. Thames water gets even sewage. Manchester water comes off the moorlands of Derbyshire, so it is pure; Edinburgh, from springs some miles from the city itself, yet is the percentage of ammonia nearly uniform. It is certain, therefore, that there are great natural processes at work, always tending to equalize the quality of all natural water that is freely exposed to air and light.

THE "VICTORIA" STONE.

[From "Engineering."]

It has always been the aim of practical workers in the fields of science, to effect a combination of material which should give a substance capable of taking the place of natural stone in the constructive arts. One of the most striking and beautiful results is witnessed in the concrete stone with which the public are now generally familiar. In a lesser degree we see the same effects produced in terra-cotta and in various forms of brick and pottery ware. In all these, however, heat is required either to effect the disintegration or combination of the elements composing the material. But an entirely new process has recently been perfected by the Rev. H. Highton for effecting the same object in which the aid of heat is entirely dispensed with. The process of manufacture is as simple as it is efficient, and consists in mixing broken granite with hydraulic cement and steeping the whole when set in a solution of silica. This manufacture is now being carried out by the Victoria Stone Company, at whose works in the Bonner road, Victoria park, we recently witnessed the process in operation. Two kinds of granite are used, Mount Sorrel and Guernsey, the former being of a brown, and the latter of a blue, color. This granite is the refuse of the quarries and is broken up into small fragments on the works. It is then mixed with Portland cement in the proportions of four of granite to one of cement, sufficient water being added to render it of a pasty consistency. In this state it is filled into the moulding frames, and is allowed to stand thus for about four days in order to dry and consolidate. After this the slab or other object is taken from the mould and placed in a solution of silicate of soda, where it remains for about two days more, when it is ready for the market.

It is in the preparation of the silicate solution that the chief merit of the invention, in a chemical point of view, lies. We need scarcely remind our readers that Portland cement, or any other concrete into the composition of which lime enters, is capable of being rendered extremely hard by immersion in the above solution. But the great cost of the silicate of soda has hitherto prevented the practical application of this fact to the commercial production of artificial stone. Besides the constant expense of renewal, there still remained the fact that the silicate of soda after losing its silica by absorption, became too caustic for workmen to handle conveniently. Working on this idea, however, Mr. Highton at length succeeded in practically solving the problem of a solution which combines economy in cost with facility in use and efficiency in results. This solution he produces in the following manner: The beds beneath the chalk formation at Farnham, Surrey, consists of a large deposit of a soft stone, containing about 25 per cent. of silica, which has this peculiarity, that it can be readily dissolved in a cold solution of caustic soda. The soda solution is placed in the tanks which are to receive the moulded concrete, and the material containing the silica is ground up and mixed with the bath. The lime removing the silica from the solution, liberates the caustic soda, which dissolves fresh silica from the Farnham stone. Hence the process is continuous, the soda acting as a constant carrier of the silica from the stone to the cement, and the bath may be kept up to the proper degree of strength, and thus the work of production may be carried on indefinitely. The cost of the silicate of soda having been once incurred, there is no further expense attending the pro-

cess of petrifying the concrete blocks than that of obtaining the Farnham stone and of using it. Mr. Highton deserves credit no less for having obtained flint in this shape, than for having applied it in this practical manner, which is as simple as it is ingenious.

The material produced by this process is known as the Victoria stone, or petrified concrete, and the principal objects which are moulded from it are flagging, sinks, mantel-pieces, coping, and cap stones, sills, stairs, and such like articles for which is is especially adapted. It is not so applicable for finer productions such as finely cut mouldings, etc., so that the company does not lay itself out for this class of work, although we brought away with us a small casting of this material, which comes out very sharp and clean. Its main value will rest in its adaptability for heavier goods, such as paving, building blocks, etc. In the former capacity it has had some fair testing in various parts of the metropolis under heavy foot passenger traffic. Some of the stone is laid in the Poultry, just in front of St. Mildred's Church, and some more on Blackfriars Bridge, the results hitherto proving most satisfactory. The Victoria stone laid is only 2 in. thick, as against York paving 3 and 4 in. thick. In the provinces, also, it has been long under trial, and is well spoken of. Being impervious to moisture, it soon dries after rain, whilst it is well able to resist frost.

With respect to the strength and durability of the Victoria stone it may be mentioned that it possesses these properties in a much greater degree a few months after manufacture than when newly made. This increase of strength is attributable to the gradual hardening by time, of the flint, which is at first thrown down in a condition resembling jelly. Thus it is found that a slab of the concrete 2 ft. wide and 2 in. thick resting loosely on supports 2 ft. apart, will bear in about 10 days' time an average weight of about 700 lbs. in the centre. After having been steeped in the silicate bath, however, it will sustain more than 1,000 lbs., whilst in five months it will carry 1,700 lbs., and in nine months as much as 2,400 lbs. Mr. Kirkaldy has tested the Victoria stone both for resistance to crushing and for transverse strength with the following results. A beam with a section of 4 in. $\times$ 4 in. made with a special view of transverse strength, resting loosely on supports 20 in. apart, sustained a weight of over 4,100 lbs. in the centre, equivalent to nearly 4 tons evenly distributed over the beam. The crushing strength of the Victoria stone was found by Mr. Kirkaldy to be 6,441 lbs. per sq in. A block of this stone presenting a surface of about 6 in $\times$ 9 in., sustained a weight of nearly 160 tons. This resistance to crushing strain points it out as well suited for foundations for heavy superstructures. Its cohesion has been proved at a London Brewery where it has been laid to replace ordinary paving which was constantly been broken by the rough handling of barrels. Since the Victoria stone has been laid not one slab has been broken, although the previous flagging required constant renewal. In fine, the Victoria stone is cheap and simple in production, and appears well calculated to successfully compete with ordinary stone in the various applications to which we have alluded.

The sinking of the ground in Turnmill street, Clerkenwell, near the Metropolitan Railway, was caused, it has been discovered, by the falling in of the sewers, caused by the flooding of the old Fleet Ditch. The inhabitants of the houses in the neighborhood have been kept for weeks in a state of alarm, and a great number have left. The railway also has been under constant supervision. Now that the cause is discovered, steps have been taken to make all secure.

It has been found that the hyposulphite of soda, which is now manufactured very cheaply, for the use of photographers, is much better than the common washing soda to wash delicate objects. It attacks neither the skin of the hands nor the objects to be washed, as does the common soda; and at the same time it is an effective bleaching agent, and takes out many spots better than any other substance.

The preliminary works for the construction of the railway from Puerto Cabello to Fonseca Bay are being proceeded with, and the plant is being supplied by the contractor, Mr. Turner; the season being favorable and the country at peace.

THE VAL-DE-TRAVERS ASPHALT PAVING FOR STONES.

From "The Mechanics' Magazine."

On the 25th ult. Mr. Haywood, the engineer and surveyor to the City Commissioners of Sewers, made an official examination as to the results of an experiment in street paving upon a new principle, in London at least, which has been upon its trial in a great thoroughfare in the city during the last year and upwards. In the early part of 1869 the Commissioners, who, among other functions, are chargeable with the maintenance of the public thoroughfares of the city, consented to a considerable part of the road-way in Threadneedle street being covered with what is called Val-de-travers asphalt, by way of test. This substance has for some years been in use in the streets of Paris on rather a large scale, without, however, being generally adopted. According to a letter written in January last by the Director of Public Ways and Footpaths there, the streets of the first and second arrondissements, comprising an area of about 100,000 square metres, will shortly be asphalted, the crossings being made of stone cubes. Comparatively speaking, he says, the streets asphalted during the last ten years have shown very good results, and such as tend to solve the problem so often propounded—namely, to construct carriage ways possessing the same advantages as those formed of granite or macadam, but without their drawbacks. The asphalt possessing a smooth surface, vehicles easily travel upon it without noise. Besides, it has the further advantage of creating neither mud nor dust, and is not slippery if properly cleansed. That in substance is the testimony, founded on experience, of the French authority to whom reference has been made. This month according to the "Moniteur Officiel" of the 15th ult., will see an extension of the asphalt roadways in the centre of Paris. The Place Louvois, the Rue Richelieu, on the part adjoining the Boulevards, and the Rue Vivienne are to be successively finished. Last year, it adds, an important part of the city was so transformed, and the whole of the district in question will receive this great improvement during the next year. In the city of London upwards of 100 owners and occupiers of premises in Old Broad street, assessed to the consolidated rate at a sum exceeding £45,000—a district long enviable for its comparative quietude—have lately memorialized the Commissioners of Sewers, urging upon them the necessity of paving it with asphalt as a remedy for the daily increasing noise and tumult consequent upon the establishment of the railway terminus at the northern end of that thoroughfare and the augmented traffic, which they say has become a great and serious annoyance to men engaged in mercantile and professional pursuits. They point for relief to the experiment in Threadneedle street, which they say has been found to answer so well, and has proved infinitely preferable to granite or any other paving now in use. In addition to the owners and occupiers in Old Broad street, several hundred firms, including bankers, merchants, stockbrokers, solicitors, and others, around the Royal Exchange and the Bank of England, have petitioned the Commissioners to the same effect. Besides being perfectly noiseless and free from dust and mud, a road so composed is said to diminish in an extraordinary degree the draught on horses. It is also remarkable for economy and durability. The experiments of yesterday are understood to have shown the wear in the pavement in Threadneedle street, although in constant use for more than a year, to have been hardly perceptible. Again, we are assured, in no case does a street once so paved require to be taken up again, except for underground repairs, and the expense of maintenance is very much less than that of macadam. It is also unaffected by heat or frost. In the formation of roads on this principle the rock is first ground, and then, having been subjected to a strong heat in a revolving boiler, by which it is not melted, it is, when in the form of powder, spread on concrete specially prepared, and being compressed with hot irons and rollers, consolidates as it cools into a mass of rock, impervious to wet, and without any joints or seams. Yesterday two pieces, each about 1 ft. square and 2 in. thick, were cut out from the roadway in Threadneedle street, in places where the traffic was supposed to have been greatest, and the result went to

show the least imaginable reduction in the thickness of the substance from wear, and the rapidity with which the roadway was afterwards reinstated in those places appeared to surprise every one who witnessed the operation. It was effected in the presence of Messrs. Callender and Amos, the managers of the Company, at whose sole expense the experiment has been made, and of Mr. Haywood, the engineer, who has to report upon the subject to the Commissioners of Sewers.

A MOUNTAIN RAILWAY IN HUNGARY.

From "The Railway News."

At a moment when the construction of cheap railways has received a new impulse through the Fairlie system, your readers may be interested in hearing of a new invention in this direction by a Hungarian gentleman, Mr. Lopresti, which was tested a few days ago, and with complete success.

There has been, indeed, for the last two years, a trial line, after this system, in use on the property of Archduke Albrecht, near Teschen, in Silesia ; but, being only about 2,000 yards in length, it gave no measure of the applicability of the system on a larger scale.

In the north-eastern part of Hungary the Crown has the extensive domain of Diriggöi, occupying a great portion of the slopes and valleys of the Pike-mountain chain, one of the three detached ranges of mountains in the heart of Hungary. The chief wealth of this domain consists of the fine oak and beech woods, which have been, however, hitherto so badly managed that they not only yielded no revenue, but scarcely paid their cost. Since the Hungarian Ministry was constituted, Mr. Lonyay, the Minister of Finance, has directed his special attention to these Crown domains. One of his creations on this field is the extension of the primitive iron-works of Diriggöi into a large establishment for the manufacture of refined iron. Partly to supply fuel for this, and partly to facilitate the transport of the wood into the neighboring country of the Theiss, a line of about 5 English miles in length has been constructed on one of the mountain valleys to the top of the ridge. The tracks were so wretched and steep, and the line so much curved, that it was quite impossible to bring down the wood by ordinary means without enormous expense. So, on this point the new system has been tried.

The line requires no permanent way at all. Square beams of oak 8 in. high and 14 in. broad are laid on the ground, and only at rare intervals, where the great unevenness of the ground absolutely requires it, cross sleepers are laid under it. Each of these longitudinal beams has a length of 18 ft. ; on the two edges of the beams are the rails, which are only 2 in. broad, and so thin that they weigh but 1 lb. per foot. These beams and rails may be taken up at any moment, and the railway thus relaid whenever it is required. The trucks run on two pairs of wheels 8 in. in diameter ; the bodies of the trucks are about three times the width of the rails, and are placed so low on the wheels that they have just room to pass over them. This, in itself, bringing the weight down so near the line, is a great guarantee against any accidents arising from the narrowness of the gauge and the severity of the curves. Besides this, there is a double brake on each truck, the ordinary brake, and then, before and behind, a couple of side wheels running outside the gauge, which may be pressed against the sides. All these precautions are taken to insure against any overturning, for on parts of the line about half of the truck is hanging over precipices, and running at the rate of some 20 to 30 miles an hour down-hill.

The top of the mountain ridge is some 700 ft. above the level of the valley, where the works are ; for about ⅓ of the distance of 5 English miles the gradient is but slight—1 or 2 in 100 ; but, further, there are gradients of not less than 1 in 16, and that for considerable distances. Even bolder are the curves. The line winds along the sides of the hills so small that there are curves of a radius of 12 yards, and those of 20 to 22 yards radius follow each other in quick succession. The trucks are taken up empty by horses, and when filled are allowed to come down by

their own impetus. The arrangement of the weight and the system of brakes is so perfect that the train may be stopped when on a gradient of 1 in 7, and going at the rate of 20 to 30 miles an hour, within 6 or 8 yards. The 5 miles cost £2,000, and after the experience now gained the work may be done for about £200 per mile.

As you may gather from the foregoing description, the object of the line in the present instance is traffic one way. And already in this respect it is invaluable in a country like Hungary, which possesses great mineral wealth and forests of inestimable value, which will become accessible at a small cost by these means, whereas otherwise they would be either altogether lost or at least imperfectly got at.

According to the calculations made since the line was opened, the square measure of wood, the transport of which cost from 4 to 5 florins, and at times could not even be transported for that sum, can now be sent down for less than one-half, and in this the sinking fund for the money invested is included. As soon as the woods along the line are cut down the line will be taken up and relaid elsewhere.

But the invention is but half complete, for the inventor has likewise designed a locomotive for his line, which will dispense with the application of horse-power, and will give the invention its full value. He has not had the means of constructing his locomotive, but now a company is to be formed, which will carry out on a large scale what answers so well on a small one. Incomplete as the system is up to the present moment, it is already of great value to Hungary. There are miles and miles of mountain forests which decay for want of means of transport, and which may be utilized by this system. The direction of the State domains has already decided to apply the system to several other domains, and others will no doubt follow. But the utility of this new system is not confined to mountain districts. There are those immense Hungarian alluvial plains, where for miles and miles not a trace of stone is found, and where an ordinary road in some cases costs as much as an ordinary railway, and is then not of much use in autumn and spring. So desperate is the case, that in some instances people have been driven to adopt the so-called clinker, or paved brick road. The laying down of lines on the Lopresti system would almost amount to the same sum as for the transport of the road metal for the regular road.

THE ABRADING AND TRANSPORTING POWER OF WATER.

From "Nature."

I.—MECHANICAL PROPERTIES OF WATER.

It is not my intention to lay down definite rules or formulæ regarding the flow of water, but rather, by drawing attention to generally acknowledged facts, to throw out suggestions which may serve to lead to the discovery of some general laws of practical use to the hydraulic engineer.

In 1857 a paper was read by me before the Royal Society of Edinburgh, "On the Delta of the Irrawaddy," in which I expressed an opinion that depth somehow affected the abrading and transporting power of water.

My experience of Indian rivers and canals during the succeeding ten years went to confirm this opinion, and before the Institution of Civil Engineers, as well as on two occasions before the British Association in 1868 and 1869, I ventured to give expression to my views of this law, as affecting artificial rivers for irrigation, and the bridging of rivers which flow through the alluvial plains of Northern India.

In the "Artizan" there have appeared during the last six months several short articles bearing on the same subject, showing how all questions relating to flowing water are affected by this supposed law, which may be stated as follows: "*The abrading and transporting power of water increases in some proportion as the velocity increases, but decreases as the depth increases.*"

The first question that arises in this inquiry is—What is water in a mechanical point of view?

This may be briefly answered by saying that it is a fluid, the particles of which,

though easily separated, do again unite, and exert a certain affinity towards each other, and also to other bodies, so that a certain amount of power is necessary to effect a separation. The attraction of the particles of water to other bodies varies with different substances; for instance, in all bodies of a fatty nature the facility for wetting is very slight; and different temperatures also affect this property of water. This attraction or force is technically known as "skin friction," and deserves the most careful investigation; for it is owing chiefly, if not altogether, to the fact that water has the power of abrasion, and it is this property which introduces the most difficult problems that a naval architect has to solve.

The affinity of one set of particles of water to another set, may possibly be measured by noting the size of a drop of water which falls from a wetted surface of a given area. By thus determining accurately the weight of water a given area can support, some approximate results of an instructive character may be arrived at; but what adds to the complication of the question is, that the cohesion of the particles probably differs according to the temperature and the purity of the water experimented on. Thus, when water reaches the boiling point, the affinity, it is believed, becomes very much lessened; and, again, it is thought that with pure or distilled water the particles probably have less affinity to each other than with water less pure. This impurity may arise from various causes; sewage, for example, would probably give much heavier drops from the same wetted area than rain-water, in the same manner that drops of treacle are much larger than those of water; that is to say, the affinity, attraction, or cohesion of the particles is as a general rule increased by the introduction of foreign matter held in solution. With solid matter held in suspension a similar result is obtained, not by increasing the cohesion of the particles of water, but by increasing the surface area wetted; for each grain of foreign matter, be its shape what it may, must have all its surface in contact with the water. This probably explains how a drop of mud should be so much larger than one of water, and, at the same time, it may possibly explain why thick muddy water, or, more properly speaking, liquid mud, with the same section and slope, cannot travel so fast as water.

From this it may reasonably be supposed that when muddy water runs down an inclined plane, the particles cannot, by their own gravity, sink so rapidly towards the bottom as to overcome the power dragging them in a different direction. As a consequence, the flow of water is retarded by having solid matter held in suspension in some proportion according to the loads on large rivers where this proportion may be only $\frac{1}{1000}$ or $\frac{1}{2000}$ part of the weight of water in motion, the retarding force may not be appreciable by the most careful experiments; so when calculating, the discharge may be left out altogether; but with torrents transporting 5 per cent. and more of solid matter, and with the discharge of sewage, it is believed that the retarding power is quite appreciable. The whole question is no doubt a very complicated one; yet by a set of careful experiments, conducted with a view to discover this adhesive power of water, it appears highly probable that an important step would be gained towards the solution of some other difficult but important problems.

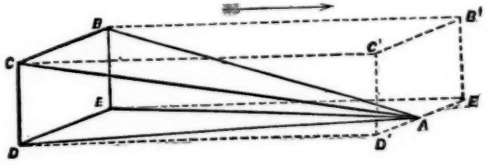
The next point to consider is—How does water travel? This also is a very abstruse question; but I believe that the true answer is given in the brief statement that water *rolls* rather than *slides*.

Were it not so, a ship with a foul bottom could not be so much retarded when passing through the water as experience shows she is. For example, supposing there are two ships in every respect the same, only that the first is covered with a coating of clean pitch a quarter of an inch thick all over her bottom to above her water line; and that the second, in place of the pitch, has got all her bottom covered with marine animals and weeds, so that when this second ship is passing rapidly through the water, none of the sea weeds or marine animals extend more than this $\frac{1}{4}$ in. beyond the ship's sides, which is the thickness of the coating of pitch on the first ship; in such a case the displacement and the lines are exactly the same, but it is hardly necessary to ask any sailor which of the two ships, with the same wind and sails, would pass most rapidly through the water, and, in the case of two steamers, the extra resistance caused by the foul bottom could be easily

measured in extra horse-power required to force the foul vessel through the water at a speed equal to the other.*

If the motion of the water was a *sliding* one only, the speed in both cases would be the same with the same power, for the resistance would be simply the separation of the two films of water, the one in contact with the ship's sides and the other with the surrounding sea; and these, in both cases, would be identical, the displacement being the same. If, however, as is believed, on a body passing through water, or water flowing down a channel, the particles of water are set in motion in a revolving direction, the convolutions increasing directly in proportion to the wetted surface, then by this hypothesis some assignable reason for this retarding of the foul-bottomed ship can be given.

If the particles slid over each other rather than rolled, they would, so to speak, pass each other in parallel straight lines; but any one in a gale of wind, going behind a high square block of building, would very soon discover that, in air, such is not the case; for if he went a few yards away in the direction the wind was blowing, he would soon discover that the building no longer afforded any protection from the blast, but that there was some certain point to leeward where the currents again converged, while beyond this the storm raged with the same violence as at any other point. (Every boatman knows what it is to get under the lee of a very high island; the sea may be smoother, but the sudden gusts of wind are often more dangerous than when exposed to the full force of the gale.) Immediately in rear of the wall itself he would find eddies of air whirling about in all directions. Within the space, A B C D E, there would be a partial protection from the storm, and instead of the wind being in the direction shown by the arrow, there would be whirling eddies



within this space, which could not exist were the air to pass off in straight lines as represented by the dotted lines B B′, C C′, D D′, E E′; neither could the several currents of air converge at the point A, which it is well known is always the case.

In the same manner any obstruction placed in a stream of water causes eddies in rear of it; that is to say, the water does not pass on in straight lines, but within this space it goes revolving about in all directions, the distance of A probably depending on the velocity; showing that there is neither a sliding motion nor a parallelism in the direction of the lines of current.†

II.—FRICTION OF WATER.

How does flowing water obtain this rolling motion? The reply to this is, By *friction*.

Take, for example, the rifling of a gun; we all know that it is owing to the spiral grooves or prominences in the chamber that the shot gets its spinning motion; but supposing the shot be a sphere, and fired from a smooth bore, it has not this rotatory motion at right angles to the line of flight, and no great dependence can be placed on its accuracy, but it may rise or fall, pass to the right or left, all depending on which side of the gun's mouth the shot touched when passing out, for so will it revolve. Should it ricochet, it will, when nearly spent, be observed to roll over the ground, and this is all caused by the friction offered by the resistance of the ground with which it came in contact. And what reason can there be assigned against water adopting this most simple of all laws for bodies in motion; and is it not owing to this that water in a cistern takes a circular motion when escaping through an orifice in its bottom, or pre-

* Possibly by the introduction of an elastic medium, such as air, between the ship's bottom and the water, the skin friction may be reduced, as it may, in a measure, reduce this rotatory action.

† By an experimental study of this subject, it may be discovered how far these eddies extend with different velocities, which may throw light on the proper length of the after portion of ships intended for different speeds.

sents a cork-screw appearance when poured out of a small vessel? Again, on the large scale, with rapid currents such as in the Pentland Frith, what but this circular motion of the stream can cause that boiling appearance given to the water, which every one must have observed who has navigated waters where there is a strong tideway? And cannot this explain why there should be an enormous breaking sea at the point where the heavy swell of the Atlantic meets the ebb tide; and does not this rolling motion given to the tide, acting in an opposite direction, check the oscillations of the Atlantic swell, causing those huge breakers so well known to the Orcadian boatmen?

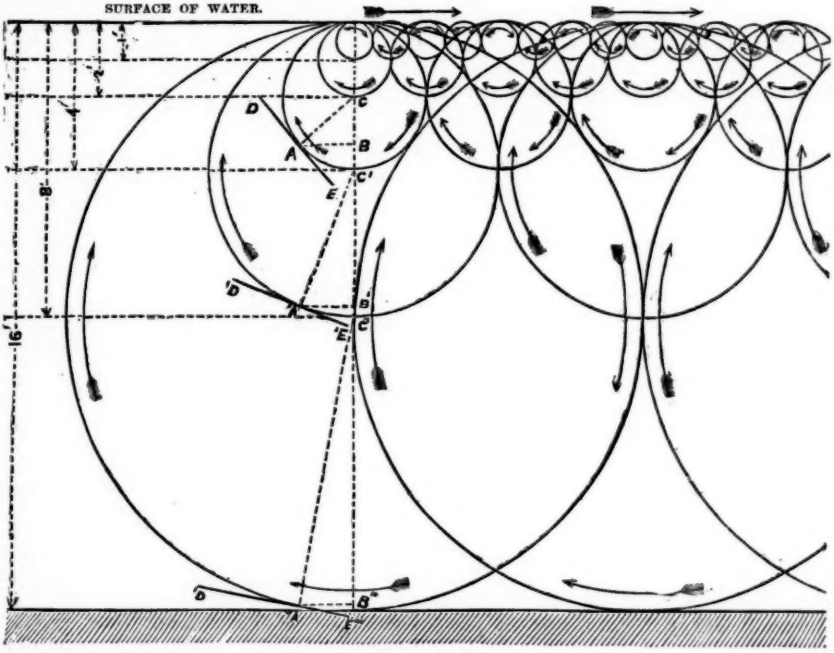
Supposing every particle of water to be a sphere in itself that can roll independently, and that a number of them being collected together form a larger sphere, which also rolls, and so on, then the diameter of the spheres increases with the depth, be it ever so great. Consequently, the facility for rolling will also increase, so that the deeper and broader a stream is—that is, the farther the centre of a stream is from the retarding medium (the bed and banks of a river)—the less is this rotatory motion obstructed; and does not this explain how the velocity increases with the hydraulic mean depth? The air also has a retarding effect even in a perfect calm; for where the Mississippi was very deep, it has been observed that the greatest velocity was not at the surface, but at some distance below it.

Supposing that water moves in an innumerable number of circles, varying from a single particle in diameter to that of hundreds of feet, and that every obstruction sets these circles revolving at right angles to their surfaces, we can at once begin to understand how, by increasing the areas exposed to friction, an innumerable set of wheels of various sizes are set spinning in all directions, but are retarded in this action by the attraction of the several particles to each other. Thus, wheels within wheels will be set in motion, some revolving in opposite directions; and the quicker the revolutions—that is, the smaller the diameter of the wheels, in other words the shallower the stream—the greater will be the power expended, which power Nature exerts in holding solid matter in suspension; therefore, if the foregoing arguments be correct, it is evident that the transporting and abrading power of water must increase in some ratio inversely as the depth, and that the retarding of a ship's sailing on a flowing river must depend on the increased area of surface exposed, thus explaining why a ship with a foul bottom, a rough, rocky bed to a river, or weeds in a stream, all retard velocity, because they one and all set so many more wheels spinning. This leads us to the important questions where abrasion and the power of flowing water to hold solid matter in suspension have to be investigated, with the view of showing how this rotatory motion acts in nature. To do so the following diagram will perhaps give a slight idea of the complicated nature of this rotation, the circles being supposed to increase in diameter with the depth. This diagram is only intended to show the relative motion of one set of particles with respect to its neighboring set of particles, each for its own depth of 1, 2, 4, 8 or 16 feet deep. Thus, where the depth is 16 feet, there would be a series of circles 16 feet in diameter, rolling within each other, where the depth was 8 ft. there would be circles of 8 ft. in diameter, and so on. That is, with the same velocity, the rotation would decrease as the diameters became greater.

The various angles with the horizon are represented by the lines D E, D′ E′, and D″ E″, which show the necessary slopes, in order that the centre of gravity of each circle should be equally beyond the point of support A′, and that consequently A B, A′ B′, A″ B″, should be all equal; they indicate that where the slope of the surface of the water remains in each case the same (say, for example, one foot in a mile), the velocity probably increases proportionally to the increased hydraulic mean depth, or that where the velocities are the same, and the depths differ, the slope requires also to vary. Let, for example, the velocity be in each case about 5 miles an hour, or some $7\frac{1}{2}$ ft. a second, while the depths are 5 ft., 8 ft., 10 ft., and 90 ft. respectively, the slopes vary from 25 ft. in the mile to only some 4 inches, while the load of solid matter held in suspension is about 7 per cent., 5 per cent., 3 per cent., and only $\frac{1}{1700}$ of the weight of water in each of the above cases respectively. With the assistance of the diagram, therefore, it will at once be seen how the whirl-

ing motion given to a stream must increase as the depth decreases, and how, by the increased agitation, the water is able to hold proportionally more solid matter in suspension, while the action on the bed of the channel must at the same time be increased.

To carry this action to extreme cases it appears evident that where the velocities are considerable, and the depths only a foot or two, the slopes must become almost precipitous, while the stream must become semi-fluid mud, or transport a large proportion of boulders, and even rocks; in doing which a certain amount of power must be expended, and in transporting this solid matter this loss of power cannot but retard the flow of the stream. On the other hand, it may be assumed that, even with considerable velocities, which at small depths would tear up and hurl forward rocks, boulders, sand and mud, with excessive depths the water may flow on in almost a compara-



tively pure state, and instead of holding in suspension stones and coarse sand, can only transport fine particles of mud.

III.—PRACTICAL CONCLUSIONS.

The following conclusions may now be arrived at:

I. That all particles of water have an affinity to each other as well as to other bodies, and that force is required to separate them.

II. That friction sets these particles rotating in all directions in larger or smaller circles, and that the friction or force increases in some proportion to the area of surface exposed.

III. That this rolling motion becomes rarer the larger the diameter of the circles may be, that is, the resistance decreases as the depth and breadth of a stream increase, or, in other words, the velocity increases proportionally to the "hydraulic mean depth."

IV. Lastly, that any increase to the rapidity of this rotatory motion, must increase the abrading and transporting power of water, by enabling it to remove from the channel of a stream grains of

solid matter, and hold them in suspension.

The following deductions are arrived at:

1. That a smooth surface offers the smallest area for the water to attach itself to, and fewer irregularities; consequently the rotatory motion given to the water is reduced to a minimum, that is, the power expended is least, or the friction among the particles of water flowing through a smooth uniform channel is less than when it flows through an irregular and rough one.

2. That in the lines of a ship not only should there be no sudden changes in direction, but the surfaces should be as smooth as possible.

3. That the area of this surface should be as small as possible; hence convex lines are preferable to concave ones, as with the same area they afford greater buoyancy, while there would be less friction for the water to roll along a convex surface than a concave one.

4. That additional length given to a ship, leaving out all other questions, must retard a ship passing through the water, by increasing the area exposed to friction; consequently there is probably some limit owing to this increased resistance, where the length midships should not exceed certain proportions of the midship section.

5. That a ship passing over shallow water must be retarded, as the diameter of the vertical circles revolving under her bottom must be less than the diameter of the circles where the water is deep; hence the smaller circles will be set in quicker rotation, and therefore loss of power ensues.

6. That the same will be the effect from the same cause where the channel is narrow and contracted.

These deductions apply to cases where the abrasion may be considered "nil," such as the discharge of water through pipes, and the sailing of ships; and the practical conclusion is, that for pipes with glazed surfaces, and ships having coppered bottoms, the water passes with the least friction.* In the case of ships, *speed* is not the only question to be considered; so the subject becomes very complicated, and though believing in the general soundness of the above deductions, the solution of these problems may be left to the naval architect to consider.

Viewing the subject on the large scale, very important conclusions are arrived at from these facts—namely, that the depth of a river depends on the nature of the materials it has got to transport; thus those which have to carry down coarse sand should be broad and shallow, while those which have to convey fine mud would naturally be narrow and deep. And as this depends on the geological nature of the catchment basin of the river, are we not naturally led to the conclusion that where we find rivers navigable, the rocks of the catchment basin which predominate are of an aqueous formation, while those rivers which are difficult of approach from the sea must drain a country where crystalline rocks predominate? Judging, therefore, on this hypothesis, are we not right in conjecturing that the rocks of Central India, and also of that vast, but hitherto almost unexplored, country, Central Africa, must be generally of a crystalline nature?

This interesting question, however, like that of the best form of ships, had better be left for the consideration of the professional inquirer, whose investigations lead him to study that branch of geology which treats of the denudation of rocks now going on on the earth's crust, and the deposits now being formed. I pass on to those questions which affect the hydraulic engineer, and they are so numerous that it would be difficult even to enumerate and classify them, while their importance is so great that it can hardly be overestimated. On this occasion only one or two of the more prominent subjects will be glanced at, more for the purpose of leading to future investigation, than to lay down rules for guidance, which at this present stage it would be premature to attempt.

* On reading over the above conclusion to an experienced ship-builder here in London, he said that one of the reasons why Aberdeen clippers sailed so fast, was owing to the smoothness of the ships' bottoms, which were first planed before the copper was put on. He also remarked that where the copper is very smoothly put on, the first place where the sheet wears through is just behind where the sheets overlap, showing that even an irregularity of one-sixteenth of an inch causes an extra action, not as might be supposed at the point of greatest obstruction, but just beyond it, proving that there must be this whirling motion which causes this abrasion. This gentleman also observed that experience showed that the speed of a ship chiefly depends on the fineness of the lines of the after rim of a ship, and that "ingoing" or concave lines should be avoided if possible.

From the foregoing remarks, suggestions, and deductions, it may be supposed that there are certain laws of nature which adapt each case to its own particular circumstances. Take, for example, the course of a river. It has been before said that streams which have to transport coarse, solid matter, such as sand, are usually broad and shallow, while those which convey chiefly fine mud are deep and narrow. The reason why those streams which convey a large proportion of sand should be broad and shallow, is that the water has thus sufficient power to hold the solid matter in suspension; and to still further aid them in this, it will be often observed that Nature generally gives such rivers, comparatively speaking, straight channels, in comparison to those which convey fine mud. The object in this case would appear to be that Nature in the former instance takes the shortest route, so as to obtain as great a fall as possible in the bed of the stream; while with the deep muddy stream, to prevent the water rushing off too fast, and so to keep up the surface of the stream to a level with the banks, or in floods often above them, Nature takes her tortuous courses, and is thus enabled year after year to deposit those fine grains of mud which add so much to the fertility of the soil.

So evidently is this the case, that in Egypt the irrigation canals are all carried in a zigzag direction, so as to check the velocity, and prevent the coarser particles of sold matter from being transported, while at the same time the surface of the water is kept at a sufficient elevation, so as to admit of easy irrigation. Thus, probably, Joseph, or whoever started irrigation in the land of the Pharaohs, took a leaf out of Nature's book; and it is by the study of this volume that the engineer of the present day will be most certain to arrive at satisfactory results.

That rivers have certain general principles by which they are governed, as to breadth, depth, slope, velocity, and load of solid matter held in suspension, it appears reasonable to suppose; and any change introduced in any one of these proportions must cause a corresponding change in one or all of the above conditions.

Thus, let there be a stream which in flood contains 5 per cent. by weight of solid matter, and let it be 8 ft. deep, discharging 50,000 cubic feet a second, with a mean velocity of $7\frac{1}{2}$ ft. a second—the breadth of this stream would be $\frac{50.000}{8 \times 7.5} = 833\frac{1}{3}$. To add one-fourth to the discharge of this stream of pure water would increase the discharge from 50,000 to 62,500 cubic feet a second, and the proportion of solid matter, instead of being 5 per cent., would be only 4 per cent. But, by the example before given, a depth approaching 9 ft. instead of 8 ft. would be the natural depth, so the bed would be lowered 1 ft., and the breadth would only be increased $\frac{12.500}{2 \times 9 \times 7\frac{1}{2}} = 92$ ft., instead of having to give an increase of one-fourth more, or $\frac{833}{4} = 208$ ft., and still keep matters much as they are found in nature.

So in bridging such a stream the whole additional length of viaduct would be only 92 ft., or 116 ft. would be saved by simply sinking the foundations 1 ft. more. But as water rolls rather than slides, and never flows in straight lines, the shape of the section of a stream can be changed at pleasure; so the depth may be increased without much danger by decreasing the breadth. Taking, then, the same stream which it was proposed to make $833 + 92 = 925$ ft. broad by 9 ft. deep, suppose the mean depth be made 15 ft., this increase of depth would decrease the transporting power, while at the same time the velocity would also be increased; and suppose it to be now 10 ft. a second, instead of $7\frac{1}{2}$ ft., and with a depth of 15 ft. with such a velocity only 4 per cent. of solid matter could be held in suspension, and the waterway would be $\frac{62.500}{15 \times 10} = 416\frac{2}{3}$ ft. broad, instead of 925 ft., or less than one-half; that is, by adding 8 ft. to the general depth of a stream where the river discharges 50,000 cubic feet a second in the main channel, and 12,500 cubic feet a second of inundation water, which is comparatively free of silt, the whole volume of 62,500 cubic feet could be passed through a bridge only half the breadth of the original stream, which was 833 ft. broad. So the whole question reduces itself now into one of cost..

The question is, whether it be cheaper to sink the foundations an extra 8 or 10 ft., or to double the length of viaduct. By

the use of the sand-pump, foundations can now be sunk through sand at a very moderate cost; so it is believed that the extra sinking would not involve anything like the cost of the shallower foundations for the bridge built on the extended plan; thus the whole cost of the superstructure and extra girders could be saved—that is, speaking approximately. In such a case the bridge built on this deep foundation principle could be built at nearly half the cost of the old plan; but to guard against accidents, and scooping out to excessive depths, it would appear that at least one-third may be saved by building bridges on this principle; while the river, by having a deep channel under the bridge, could be kept in better control than by the present extended method, as it would not have such a tendency to desert its course, but would always keep to the deep channel.

Several other examples may be brought forward to illustrate the practical advantages that a better knowledge of the action of flowing water would be sure to confer on science and hydraulic engineering; but it is hoped that the foregoing will assist in bringing the importance of the subject more prominently forward. When once the subject is properly discussed I am convinced its importance will be manifested.

T. Login.

EXPERIMENTS FOR MAKING BRICK MASONRY IMPERVIOUS TO WATER.

Abstract of a paper read before the American Society of Civil Engineers, May 4, 1870, by William L. Dearborn, Civil Engineer, Member of the Society:

The face walls of the Back Bays of the Gate-houses of the new Croton Reservoir, located north of Eighty-sixth street, in Central Park, were built of the best quality of hard-burned brick, laid in mortar composed of hydraulic cement of New York, and sand, mixed in the proportion of one measure of cement to two of sand. The space between the walls is 4 ft., and was filled with concrete. These face-walls were laid up with great care, and every precaution was taken to have the joints well filled and insure good work. They are 12 in. thick and 40 ft. high, and the Bays, when full, generally have 36 feet of water in them.

When the Reservoir was first filled, and the water was let into the Gate-houses, it was found to filter through these walls to a considerable amount. As soon as this was discovered, the water was drawn out of the Bays, with the intention of attempting to remedy or prevent this infiltration. After carefully considering several modes of accomplishing the object desired, I came to the conclusion that the mode known in England as "Sylvester's Process for Repelling Moisture from External Walls," was the easiest of application, and would be as effectual as any; and, on consulting Dr. Chilton, the chemist, I was confirmed in this opinion.

The results of the investigation were then submitted to A. W. Craven, Engineer of the Croton Water Works, for his decision, and his instructions were to adopt Sylvester's process.

This process consists in using two washes or solutions for covering the surface of brick walls; one composed of Castile soap and water, and one of alum and water. The proportions are: three-quarters of a pound of soap to one gallon of water, and half a pound of alum to four gallons of water, both substances to be perfectly dissolved in the water before being used.

The walls should be perfectly clean and dry, and the temperature of the air should not be below 50 deg. Fahrenheit, when the compositions are applied.

The first or soap wash should be laid on, when at boiling heat, with a flat brush, taking care not to form a froth on the brickwork. This wash should remain 24 hours, so as to become dry and hard before the second or alum wash is applied, which should be applied in the same manner as the first. The temperature of this wash, when applied, may be 60 or 70 deg., and it should also remain 24 hours before a second coat of the soap wash is applied, and these coats are to be repeated alternately until the walls are made impervious to water.

The alum and soap thus combined form an insoluble compound, filling the pores of the masonry and entirely preventing the water from penetrating the walls.

Before applying these compositions to the walls of the Bays, some experiments were made to test the absorption of water by bricks under pressure, after being covered with these washes, in order to determine how many coats the walls would require to render them impervious to water.

To do this, a strong wooden box was made, put together with screws, large enough to hold two bricks, and on the top was inserted an inch pipe, 40 ft. long.

In this box we placed two bricks, after being made perfectly dry, and then covered with a coat of each of the washes, as before directed, and weighed. They were then subjected to the pressure of a column of water 40 ft. high, and, after remaining a sufficient length of time, they were taken out and weighed again to ascertain the amount of water they had absorbed.

The bricks were then dried, and again coated with the washes and weighed, and then subjected to pressure as before; and this operation was repeated until the bricks were found not to absorb any water. Four coatings rendered the bricks impenetrable under the pressure used.

The mean weight of the bricks (dry), before being coated, was $3\frac{7}{8}$ lbs.; the mean absorption was one-half pound of water.

An hydrometer was used in testing the solutions.

As this experiment was made in the fall and winter (1863), after the temporary roofs were put on to the Gate-house, artificial heat had to be resorted to to dry the walls and keep the air at a proper temperature.

The cost was 10.06 cts. per square foot.

As soon as the last coat had become hard, the water was let into the Bays, and the walls were found to be perfectly impervious to water, and they still remain so.

BRICK ARCH (FOOTWAY OF HIGH BRIDGE).

The brick arch of the footway of High Bridge is the arc of a circle 26 ft. 6 in. radius, and is 12 in. thick; the width on top is 17 ft., and the length covered was 1,381 ft.

The arch, for 8 in. in thickness, rests on cast-iron skewbacks, which are prevented from separating by wrought-iron tie-rods.

The two first courses of brick of the arch are composed of the best hard-burnt brick, laid edgewise in mortar composed of one part, by measure, of hydraulic cement of New York, and two parts of sand.

The top of these bricks, and the inside of the granite coping, against which the two top courses of brick rest, was, when they were perfectly dry, covered with a coat of asphalt one-half an inch thick, laid on when the asphalt was heated to a temperature of from 360 to 518 deg. Fahrenheit.

On top of this was laid a course of brick, flatwise, dipped in asphalt, and laid when the asphalt was hot, and the joints were run full of hot asphalt.

On top of this a course of pressed brick was laid, flatwise, in hydraulic cement mortar, forming the paving and floor of the Bridge. This asphalt was the Trinidad variety, and was mixed with 10 per cent., by measure, of coal tar, and 25 per cent. of sand. A few experiments for testing the strength of this asphalt, when used to cement bricks together, were made, and two of them are given below.

Six bricks pressed together, flatwise, with asphalt joints, were, after laying six months, broken.

The distance between the supports was 12 in.; breaking weight, 900 lbs.; area of single joint, $28\frac{1}{2}$ square in. The asphalt adhered so strongly to the brick as to tear away the surface in many places.

Two bricks pressed together, end to end, cemented with asphalt, were, after laying six months, broken.

The distance between the supports was 10 in.; area of joint, $8\frac{1}{2}$ square in.; breaking weight, 150 lbs.

The area of the Bridge covered with asphalted brick was 23,065 square ft. There was used 94,200 lbs. of asphalt, 33 barrels of coal tar, 10 cubic yards of sand, 93,800 bricks.

The time occupied was 106 days of masons and 148 days of laborers. Two masons and two laborers will melt and spread, of the first coat, 1,650 square ft. per day. The total cost of this coat was 5.25 cents per square foot, exclusive of duty on asphalt. There were three grooves, 2 in.

wide by 4 in. deep, made entirely across the brick arch, and immediately under the first coat of asphalt, dividing the arch into four equal parts. These grooves were filled with elastic paint cement.

This arrangement was intended to guard against the evil effects of the contraction of the arch in winter, as it was expected to yield slightly at these points and at no other point, and then the elastic cement would prevent any leakage there.

The entire experiment has proved a very successful one, and the arch has remained perfectly tight.

NOTE BY GEN. GEORGE S. GREENE.

In proposing the above plan for working the asphalt with the brickwork, the object was to avoid depending on a large continued surface of asphalt, as is usual in covering arches, which very frequently cracks from the greater contraction of the asphalt than that of the masonry with which it is in contact, the extent of the asphalt on this work being only about one-quarter of an inch to each brick.

This is deemed to be an essential element in the success of the impervious covering.

THE STRENGTH OF IRON AND STEEL.

From the "Building News."

At the last meeting of the Institution of Civil Engineers a paper was read "On the Strength of Iron and Steel, and on the Design of parts of Structures which consist of those materials," by Mr. George Berkley.

The author stated that the strength of wrought-iron varied with the quantities of work involved in the production of the form of the material tested. This was proved by the fact that a bar of iron 1 in. sq., which would break with a strain of 26 tons, would, if drawn to the form of wire $\frac{1}{32}$ of an in. in diameter, bear a strain of 40 tons per sq. in. The strength to be relied on in practice would probably be best represented by the minimum strain that 1 sq. in. would bear without rupture, and by the amount of stretch which would take place in a given length before it broke. Iron could be obtained at the current market rates which would bear the following strains: For plates, an average breaking strain of 20 tons per sq. in., and a minimum breaking strain of 19 tons per sq. in., and an average stretch of 1 in. in 12 in. lineal. For L and T irons an average breaking strain of 22 tons per sq. in., and a minimum breaking strain of 21 tons per sq. in., and an average stretch of $1\frac{1}{4}$ in. in 12 in. lineal. For rivet iron an average breaking strain of 16 tons per circular in. For bars intended for chains, couplings, etc., an average breaking strain of 22 tons per sq. in., and an average stretch of $1\frac{3}{4}$ in. in 12 in. lineal. For ordinary classes of work, let at competitive prices, stronger iron could only be obtained with difficulty.

In the consideration of the practical limit of strain to which 1 sq. in. of wrought-iron could with safety be subjected, and the principle on which such a limitation rested, the erroneous impression as to the degree of strain being 10 tons or 12 tons per sq. in. which first produced "permanent set" was pointed out, as well as the apparent discrepancy between the results of ordinary observation and of minutely manipulated experiments, such as those of Sir Wm. Fairbairn and Mr. E. Clark, was noticed, wherein permanent set had been observed after 3 tons per sq. in. had been imposed on the iron, and was explained by the difficulty of registering such small amounts of set as $\frac{1}{1250}$th part of an in. in 5 ft., which resulted from a strain of 10 tons per sq. in.

Attention was drawn to the fact that upon the application to 1 sq. in. of wrought-iron of strains exceeding about 12 tons, the measure of stretch per unit of strain, which had previously increased in a certain proportion to the units of strain applied, increased with a greater and progressive rapidity. It was also noted that the amount of stretch actually produced by the imposition of a strain of about 12 tons per sq. in., would be sufficient frequently to preclude the use of wrought-iron so strained.

In illustration of the effect of the repetition of strains on iron and steel, it was stated that with blows powerful enough to bend bars of cast-iron through one-half of their ultimate deflection (that was to say, the deflection which corresponded to their fracture by dead

pressure) no bar was able to stand 4,000 of such blows in succession. And also, that when the bar was thrown into a violent tremor, then "when the depressions were equal to one-half of the ultimate deflection, the bars were broken by less than 900 depressions." A piece of rail, weighing 68 lbs. per yard, made of Bessemer metal, which, when placed on firm bearings 3 ft. apart, bore one blow from a weight of 1 ton falling through 30 ft. without breaking, though bending about 7 in., broke with a weight of $3\frac{3}{4}$ cwt., falling 15,400 times through heights increasing from 1 ft. to 10 ft. by increments of 6 in. each time. With wrought-iron, it appeared from an experiment of Sir Wm. Fairbairn that when it was desired to repeat the application of strains from 2 to 3 million times it would not be prudent that such strains should exceed 7 tons per sq. in. of section.

It appeared from these considerations that the practical strength of wrought-iron in structures of a permanent character could not be estimated at more than 12 tons per sq. in. when such an amount of strain was repeated more than a small number of times; and that it should not be calculated as exceeding 7 tons per sq. in. when strains of this amount would be applied to it many times daily. In some of the principal suspension road bridges, it was said that a maximum of about 9 tons per sq. in. of section in tension was imposed on extraordinary occasions, while railway bridges were frequently subjected to the maximum calculated strain, a limit of 5 tons being in this country generally adopted. From this practice it was assumed that a margin, for errors of design and for other practical defects, of only 25 per cent. was allowed in permanent structures. The importance of sound principles of design was therefore manifest. The parts most difficult to design were the connections of portions of the structure with riveted joints. It was desirable that the area of the section of the rivets to be sheared, as well as of the plates forming these connections, should be somewhat in excess of the sectional area of the plates or bars which they connected; and that as the process of punching the rivet-holes in the plates, etc., had a tendency to weaken them in a greater proportion than that in which the area was decreased, it was advantageous to drill all rivet-holes in parts exposed to tension. It was represented that the general principles of design were well illustrated by a joint made of a single pin, such as that used in suspension bridges, Warren girders, etc. Examples of various forms of links were presented for consideration, and a form of link of equal thickness, but with an enlarged head, was said to have been proved by experiment to be of about equal strength in all its parts. The proportions of these links were as follows:

The bar	A	being 100
The diameter of pin	B	= 74
The depth of head beyond pin	C	= 100
The two sides of the pin-hole	D D	= 125
And the radius of the curve of neck	R	= 150

Links of these proportions, with larger pins and narrower sides—Nos. 7 and 7a—and larger pins and sides of the same width, Nos. 8 and 8a, made of iron of exactly the same strength, and links of proportions precisely similar to those adopted for the Menai, Nos. 9 and 9a, the Pesth, Nos. 10 and 10a, the Chelsea, Nos. 11 and 11a, and the Hungerford, Nos. 12 and 12a, were compared. Taking the strength of the standard form, 22,125 tons per sq. in. of bar area, as = 100, the percentage of gain or loss in power of resistance to ultimate strain by the use of the other forms of links as follows:

6 and 6A	= 100		
7 " 7A	= 79.9; loss =	21.1	per cent.
8 " 8A	= 104.7; gain =	4.7	"
9 " 9A	= 92.0; loss =	8.	"
10 " 10A	= 79.8; " =	21.2	"
11 " 11A	= 89.2; " =	10.8	"
12 " 12A	= 85.4; " =	14.6	"

The necessity for strengthening the heads of links, and for testing all of them with a strain equal to at least 10 tons per sq. in. of bar, was proved, it was believed, by the experiments quoted, and by the evidence of Mr. Provis in his work on the Menai Bridge. It was urged that an examination of the diagrams would show that some links failed with a less degree of stress, on account of the junction of the mass of the head with a comparatively smaller section of bar, by means of a curve of too short radius. This imperfect principle of construction also operated in causing fracture across the centre of the heads on both sides of the pin-hole; and in such designs, the question of the direction of the strain being truly along the axis of the link or

bar, and of the strength of the material on both sides of the head being equal, should be considered.

The author next directed attention to the unsatisfactory state of the knowledge of the profession respecting the power of struts of various proportions and forms to resist compression, and stated his belief that the formulæ which had been proposed to facilitate calculations for determining the strain which such columns would bear, produced results which neither agreed one with the other, nor with any series of such experiments as had been tried. It seemed probable that for the present, error might be best avoided by referring to the results of experiments made upon columns, etc.; the conditions of which were analogous to the case under consideration.

With respect to cast-iron, it was stated that a mixture of iron for sleepers had produced bars, 2 in. by 1 in. in section, which, when placed on bearings 3 ft. apart, had on the average of 1,151 experiments during the last three years borne 33.4 cwt. placed on the centre, and castings, 1½ in. in length and exactly 1 in. square, which on the average of 1,002 experiments had borne 13.07 tons of tensile strain. An attention to the amount of deflection of the test-bars had been beneficial, the average strain required to break the sleepers have been raised since the amount of deflection of the bars with a given weight had been increased. For the purpose of comparing the comparative strength of precisely similar girders cast with iron of varying degrees of strength, as represented by the ordinary test-bars, and when subjected to a direct tensile strain, the experiments detailed in the Appendix (Table No. 7) were tried, the girders being cast of the exact form and dimensions of three of those described in Sir William Fairbairn's "Researches on the Application of Iron to Buildings." The results were as follows :—

The strength per square inch of section was represented in Girder No. 1, by

Mr. Fairbairn's experiments ..... as = 3214 lbs.
The first series of special experiments ..... as = 4977 "
The second series of special experiments ..... as = 4977 "

In Girder No. 2 by

Mr. Fairbairn's experiments ..... as = 3346 lbs.
The first series of special experiments ..... as = 5264 "
The second series of special experiments ..... as = 5308 lbs.

In Girder No. 3 by

Mr. Fairbairn's experiments ..... as = 4075 lbs.
The first series of special experiments ..... as = 4988 "
The second series of special experiments ..... as = 6300 "

The strength of the test-bars and the tensile strength of the iron used by Sir Wm. Fairbairn was not stated; but it might be assumed to be equal to about 25 cwt. placed on the centre of the bars, between bearings 3 ft. apart, and to a tensile strength of about 7 or 8 tons per square inch. The strength of the iron employed in the special experiments was represented by a weight supported by the test-bars varying from 30 cwt. to 38 cwt., and by a tensile strength varying from 10.25 tons to 13.94 tons.

In order to secure these results, the following conditions were represented as important, and should be considered in the design and execution of cast-iron work :

1*st*. The strong iron referred to was obtained by the mixture in the furnace of four or five brands, some being harder than others. In order to amalgamate, as far as possible, these different qualities of iron, the furnace should be charged with them mixed in proper proportions in every basketful of metal which was emptied into it. 2. There would be a difference of about 16 per cent. between the weight that a 2-in. by 1-in. test-bar would support when cast on edge and proved as cast, and that which it would support when proved with the under-side as cast placed at the top as proved ; and a difference of about 8 per cent. between the weight the same test-bar would support if cast on its side or end, and proved on edge. This difference it would be necessary to take into consideration in estimating the strength of a large casting made from the same metal as that used in the test-bars. Another, and probably the most important practical consideration, in respect of the strength of castings, was the proportions of their several parts being such as would free them as much as possible from unequal contraction in cooling. It was not often practicable to effect that which would avoid this, viz., to adopt an equal thickness of metal in all parts of the casting ; and it was therefore important that some means

should be taken to prevent the castings from cooling too quickly.

The author drew attention to the experiments which had lately been tried with steel—more especially Bessemer steel—which experiments he considered justified the adoption of the following conclusions:

1*st*. That Bessemer steel would bear before rupture a minimum tensile strain of 33 tons per square inch of section and stretch about 1 in. in 12 in. of its length. 2*nd*. That the same material would bear either in tension or in compression a minimum stress of 17 tons before the extensions or reductions of length per unit of strain became irregular or excessive, as compared with those which had preceded them,—in other words, before the yielding point of the material was reached. 3*rd*. That this material probably contained about .45 per cent. of carbon chemically combined with the iron. And 4*th*. That this description of steel, if properly made and annealed, was as uniform in quality as wrought-iron—and therefore might be employed (precautions being taken to test its quality as a substitute for wrought-iron) while allowing an increase of strain of 50 per cent. to be imposed upon it.

EXPERIMENT ON THE EVAPORATION OF A CORLISS BOILER.

By JAMES B. FRANCIS, Civil Engineer.

The experiment was made on one of the 4 Corliss boilers in the mills of the Merrimack Manufacturing Company at Lowell, Massachusetts, constructed by the Corliss Steam Engine Company of Providence, R. I., and first put in operation in October, 1868.

Each boiler consists of a central cylinder, about 24 ft. high and 42 in. in diameter, standing vertically on the floor of the boiler-house, and containing no tubes or flues, but surrounded by an annular grate, about 12 ft. in diameter, with 8 fire doors on its exterior circumference. Hanging vertically from the sides of the central cylinder, are 6 other cylinders, about 14 ft. long and 40 in. in diameter, each containing 61 vertical tubes, 2 in. internal diameter, and about 14 ft. long. Each of the tubular cylinders is connected with the central cylinder by 3 pipes, about 7 in. long; those near the top and bottom of the tubular cylinders being about 9 in. in diameter, and the intermediate pipe, which is a little below the usual water line, is about 15 in. high and 6 in. wide.

The usual height at which the water is kept is at the 5th gauge cock, which is about 3 ft. below the tops of the tubular cylinders, and about 9 ft. below the top of the central cylinder.

The products of combustion rise on the outsides of all the cylinders to within about 2½ ft. of the usual water line. There is, however, no outlet for the gases except through the 366 tubes in the tubular cylinders; the lower 11 ft. of the length of the tubes being usually surrounded by water, and the upper 3 ft. by steam. After passing through the tubes the gases enter a chamber concentric with the central cylinder, and extending about 14 ft. above the top of the tubular cylinders, giving just sufficient height to take out the tubes. From near the top of this chamber the gases pass off by a horizontal flue of sheet iron, about 6 ft. wide and 1 ft. high, to a chimney, 200 ft. in height.

The 7 connected cylinders forming the boiler are enclosed by a cylindrical wall of brickwork, which confines the gases and supports the feed-water tank. The draft is regulated by means of a damper in the horizontal sheet iron flue, and by the 8 ash-pit doors, which are well fitted, and open into a common ash pit. Usually one of these doors was open from a quarter to a half, and the damper in the flue also open about one half. The fire doors were made of two parallel plates of iron, 2 or 3 in. apart, with 6 air holes, ⅜ths of an inch in diameter, through the outer plate, and a greater number through the inner plate; said to be for the purpose of preventing the doors from becoming too much heated. The powerful draft causes a large quantity of air to pass through these holes and enter the space above the fire, apparently much in excess of what is necessary for the combustion of the gases.

The top of the chamber is covered by an open tank about 18 in. deep, in which the feed water is usually heated, but

which was not used for that purpose in this trial.

The passage of the heated gases over surfaces of the boiler above the water line, of course, tended to superheat the steam, and observations of the temperature of the steam, as well as its pressure, were made to ascertain the amount of the superheating.

The amount of the heating surface, not including the feed-water tank, is as follows :

	SQ. FEET.
Area of heating surface on outside of the 7 cylinders, connecting pipes, etc..	1277.56
Tube surface	2679.01
Total heating surface.....	3956.57
Area of grate surface	103.27
Fire surface to each square foot of grate surface	38.31
Usual thickness of fire 6 to 8 in., average about	7 in.

For convenience of feeding with water from the water tank, the north-easterly boiler was selected for trial. I am informed that this boiler has been in use uniformly since it was first started, stopping regularly with the others, one week in four, for cleaning and examination. It was stated by Mr. Austin, the engineer in charge, that this boiler was blown off last four or five weeks before the commencement of the trial. It had been stopped one week in its turn just previous to the commencement of the trial, during which time the water was drawn out of it, and the fire surfaces of the tubes and other parts cleaned; nothing, however, being done beyond the usual monthly cleaning.

The trial consisted in measuring the quantity of water evaporated, and weighing the coal burned, during 120 hours of continuous firing, from Monday, March 21st, 1870, at noon, to the following Saturday at noon. It was designed to maintain the firing and pressure of steam uniformly, night and day, throughout the trial, but it was not found to be convenient to maintain the pressure fully during the night; the mean pressure during the day being about 68.60 lbs. above the atmosphere, and during the night about 65.02 lbs. Fire was made up under this boiler early in the morning of Monday, March 21st. The usual custom is to clean out the clinkers from the grate and make up the fire at 11 o'clock, A. M., which gives a fire in its best condition about one hour afterwards. This was done in this trial, and the water brought to the usual height of the 5th gauge cock at noon, when the trial commenced. All the ashes were then removed from the ash pit, and all the coal in the vicinity of this boiler removed from the floor, and the coal weighed out for the trial put in its place. At the end of the trial the firing was done, as nearly as practicable, in the same manner, the fire being left in its best condition, with the usual quantity of coal on the grate, and the water at the 5th cock.

The quantity of water evaporated was measured in a large wooden tank, constructed for the purpose of heating water for use in the Calico Print Works of the establishment, with part of the exhaust steam from the engine. For this purpose it was detached from its usual connections, and connected only with the force pumps supplying this boiler. The contents of the tank for the 5 ft. in depth, gauged by measurement for this purpose, was 3,316.24 cubic ft. This quantity was not all used before refilling. It was filled up 5 times during the trial, or once each day, and the quantity drawn from each filling noted. The whole quantity drawn was 11,405.017 cubic ft., at the mean temperature of 37.97 deg. Fahr., or 711,456.37 lbs.; allowance being made for a small leakage, and for a slight enlargement of the tank when filled, the dimensions having been taken when empty.

The coal used was white ash anthracite, from the Preston and Gilberton mines, taken from a lot of about 14,000 tons received during the year 1869; part of it was exposed to the weather and part of it stored under sheds. It was taken without selection, but I have learned, subsequently to the trial, that about half a ton of slaty lumps was thrown out in the boiler-house, and an equal quantity of purer coal substituted. The coal was weighed on platform scales, 2 tons at a time; the scales having been previously adjusted to weigh accurately, by the official sealer of weights and measures for the city of Lowell.

The total amount of coal weighed out for the trial was	85,120 lbs.
Of this, not put on grate ..	2,076 lbs.
Cinders picked out from ashes at end of trial, that might have been burned, but could not conveni-	

ently be returned to the grate during the trial....	1,112.5 "	
		3188.5 "
Total amount of coal burned		81931.5 "

The temperature of the feed water was observed in the feed pipe near the force pumps, by a thermometer, the bulb of which was inserted in the pipe and exposed to the current, the scale projecting through a packed joint. The pressure of the steam was observed by an Ashcroft gauge in the steam pipe between the boiler and the 1st valve. The temperature of the steam was observed in the steam pipe, close to the pressure gauge, by means of a thermometer inserted in a tube filled with oil, fitted into the pipe. The temperature of the gases escaping from the boiler was also observed by means of a similar tube, filled with oil, inserted in the sheet-iron flue, about 10 in. from the chamber over the boiler. The temperature of the air in several places was also observed. All the thermometers used have been tested since the trial by Huddleston, the well known thermometer maker, of Boston, and the pressure gauge by the American Steam Gauge Company, of Boston. In the results given the corrections have been applied :

Mean temperature of water in feed pipe (extremes 41.6° and 36.5°.....	37.97°
Mean temperature of steam in steam pipe (extremes 322° and 294°).....	311.8°
Mean pressure of steam in steam pipe above the atmosphere (extremes 79 lbs. and 45.5 lbs.).....	66.46 lbs.
Mean temperature of gases in flue (extremes 355° and 208°).....	286.4°
Mean temperature of air in boiler-room, at thermometer 5 feet above floor (extremes 82.5° and 55°....	73.4°
Mean temperature of air in boiler-room, at thermometer 40 feet above floor (extremes 130.5° and 107.7°).....	117.7°
Mean temperature of air out-doors, in shade (extremes 51° and 19°)	33.9°
Water evaporated from the initial temperature of 37.97° by each pound of coal $= \frac{711456.37}{81931.5} =$	8.684 lbs.

To reduce this to the evaporation from 212°, I use the formula given by Rankine, at page 254 of his "Manual of the Steam Engine," viz. : $h_{2\cdot1} = 1092 + 0.3\,(T_1 - 32°) - (T_2 - 32°)$. In which, $h_{2\cdot1} =$ the multiplier of the observed weight of water evaporated by each pound of fuel, which, being divided by 966, gives the weight of water which would have been evaporated by each pound of fuel, had the water been both supplied and evaporated at the boiling point corresponding to the mean atmospheric pressure.

T_1 = the temperature of evaporation (see below).....	299.46°
T_2 = the temperature of the feed water = ...	37.97°
Substituting the values for T_1 and T_2 we have $h_{2\cdot1} =$	1166.27
And the equivalent amount of water, if supplied and evaporated at 212° = $8.684 \times \frac{1166.27}{966} =$.....	10.484 lbs.

As above described, the boiler is so constructed that the heated gases all pass through the tubes, the upper 3 ft. of their length being above the water line. The exterior of the upper 9 ft. in height of the central cylinder, which is steam space, is also exposed to the heated gases. The effect of this arrangement being, of course, to superheat the steam.

The observed mean pressure of the steam, per square inch, above the atmosphere, was.....	66.46 lbs.
The temperature of saturated steam, of this pressure, according to Regnalt, as given in the table in the "Description of Richards' Improved Steam Engine Indicator," by Chas. T. Porter, London, 1868, is	299.46°
Mean observed temperature of the steam.....	311.80°
Excess of the observed temperature, being the amount the steam is superheated	12.34°

The superheating being part of the useful effect of the fuel, its equivalent in evaporation of water should be added to the results obtained above.

The specific heat of steam being, according to Rankine, 0.475, that of water being 1. The equivalent evaporation of water from the initial temperature, due to the superheating is $\frac{0.475 \times 8.684 \times 12.34}{1166.27} =$....	0.044 lbs.
Which added to 8.684 lbs., gives for the equivalent evaporation from the initial temperature	8.728 lbs.
The equivalent evaporation from 212°, due to the superheating, is $\frac{0.475 + 10.484 \times 12.34}{966} =$.....	0.064 lbs.
Which, added to 10.484 lbs., gives for the equivalent evaporation from 212°	10.548 lbs.

When in ordinary use, the temperature of the feed water is sensibly raised by pas-

sing through the tank over the boilers; this is, of course, part of the duty of the boiler, and its equivalent in evaporation should be added to the above in order to give the total evaporative power of the boiler. In this trial the feed water was not so heated, and I have no means of ascertaining to what extent it would have been heated if it had passed through the tank in the usual manner; I therefore do not attempt to allow for it.

The amount of clinkers was	3261.0 lbs.
" " ashes "	1322.5 "
Amount of clinkers and ashes not returned to the fire	4583.5 "

Or about 5½ per cent. of the coal burned.

COLD BLAST, WARM BLAST, HOT BLAST.

Correspondent Lake Superior "Mining Journal."

The last two are relative terms; and, considering that the natural temperature of the air varies from 100 deg. above to one-half as many deg. below zero, in this latitude, strictly speaking, all are relative terms. In the iron trade of this country, however, a blast heated up to not exceeding 450 deg. Fahrenheit is said to be warm; from that up to the melting of lead, and somewhat above, has been called hot blast. But of late some of our furnaces reach 900 deg., and in England 1,200 deg. is said to have been attained. If we retain the nomenclature which forms our heading, a new term will have to be added—we suggest red-hot blast. And this is the literal fact: air and all other substances begin to show a dull red at between 900 deg. and 1,000 deg. Furnaces are now running in Pennsylvania where the goose-neck pipes are so hot as to light up the tuyere arches at night.

One advantage of heating the blast is very apparent; cast-iron melts at about 2,800 Fahr. Now, all air going through the furnace must be raised to this temperature. If we put the air into the furnace at 400 deg., we evidently save one-seventh of the fuel required to heat the air; a very important item when we consider that it takes about 10 tons of air to produce 1 ton of iron.

But this is not the whole, nor even the greatest advantage, as all know who have made hot and cold blast iron in the same furnace, for experience shows that the saving of fuel is from 20 to 50 per cent., in using hot against cold blast, and the make increased in a still greater proportion. This is due to the increased chemical affinity found to exist between heated air and coal. Combustion takes place more rapidly, hence is more intense and concentrated. No more units of heat are evolved, but the combustion is confined to the more immediate vicinity of the tuyeres. It is well known that cold-blast furnaces are hotter in the upper parts than hot-blast furnaces, while in the latter the zones of reduction and melting are lower down in the furnace. The gases raising from this deep-seated region of greatest heat give out their caloric to the descending stock, thus thoroughly preparing it, and finally leave the furnace mouth at a lower temperature than those of cold-blast furnaces.

The reason of the increased intensity of combustion due to heated air has been explained by supposing the rarefied oxygen to more easily permeate the pores and interstices of the fuel, thereby increasing the surface exposed to the oxidizing influence. Whatever the explanation, the fact is established that hot blast produces iron faster in any given furnace, and with less fuel than cold blast. No limit has yet been found. Theoretically there must be carbon enough to act as a reducing agent; but practically the amount of heat that can be employed seems likely to be limited by the difficulty of keeping joints tight and working about highly heated pipes.

As to its effect on the quality of the iron produced, there has been much discussion. When we consider that within the experience of many of our older iron masters, all the iron made in the world was cold blast, and that now it is nearly all hot, we need have no serious apprehensions as to the future of the hot-blast metal. Producers and consumers of cold-blast iron who had made money in the trade, were naturally opposed to any change which looked to a rebuilding of their furnaces and a revising of their traditions.

Iron workers are conservative. Again

there is a universal belief among men that what costs the greatest amount of time, material, and money to produce must be the best (and it is not a bad general rule), hence that this cheaply-produced, new-fangled pig metal was of an inferior quality. Again the hot-blast men soon found that they could produce good metal from sulphurous and other inferior ores that had before been considered worthless. This was bringing "good out of Nazareth," and was against them. But time has changed all this; it would not now be possible to make all the iron consumed in the world if done by cold blast. English hot-blast mineral fuel iron is now put to some of the most trying and important uses, for which a short time ago only cold-blast charcoal iron was deemed fit.

But there is often a difference between cold and hot-blast iron, and it is not improbable that some ores may produce a better iron worked cold than hot, in the present state of iron metallurgy.

Intense heat in the furnace tends to reduce the silica and leave its metal silicon in the pig, where it is objectionable for some uses, particularly for bar iron. This can generally be corrected by using a larger amount of lime, which, uniting with the silica, carries it off in the slag. It would be well for furnace men proposing to raise the temperature of their blast, to bear this in mind.

To illustrate and apply these suggestions in Lake Superior practice, let us look for a moment at the Deer Lake Furnace.

The stack is 33 ft. high, 7 ft. 8 in. bosh, hence probably the smallest furnace built in the United States within five years, and in this particular a grave mistake. The furnace runs but six days in a week, banking up Saturday night at 12 o'clock, and starting again the following midnight. This practice we believe to be a mistake, not only from the money-making standpoint, but on true moral and religious grounds; but it is neither to the size of the furnace nor to its religion we desire to call attention here, but to *its enormous hot-blast oven*, and the remarkable results it is producing.

This oven, arranged on Player's plan, contains 45 tons of metal, which is 50 per cent. more than found at our largest charcoal furnaces having twice the capacity of the Deer Lake stack. The furnace is driven by water, hence all the gas is available for heating the blast, and being all collected by the cone and thimble arrangement, is burned in the great oven which heats the blast near to red hot. Messrs. Ward & Hall have no means of measuring the temperature; they only know that it is a great deal hotter than the melting of lead.

As to results: the furnace has averaged 11 tons per day for three weeks on 110 bushels of coal per ton, one-half of which was soft coal, mostly pine tops. New York Company's hard ore only was used, averaging 66 per cent.

We know that somewhat better work has been done, but considering the great disparity in the size of the furnaces, and the inferior quality of the fuel used at Deer Lake, and the weekly stoppages, this is extraordinary work.

We also know that the concern is very well managed, but believe that the above record is chiefly due to a very large hot-blast oven, and to the fact that all the gas is available for heating the blast.

Application: Proprietors and managers of hot-blast water furnaces, running on L. S. ores, had best follow the lead of the Deer Lake—tear down their ovens and build larger. The thanks of the charcoal ironmakers of this region are due to Mr. Ward for having pioneered *red-hot blast* into Lake Superior practice.

If any furnace man wishes to know about how much money it is costing him to support the magnificent flame out of the mouth of his furnace, let him build a fire of corresponding size on the fill plate, feeding it with charcoal at 13 cents per bushel (stumpage and kiln rent in); he will know at the end of a month what it costs to be a "fire worshipper."

M. Riche, in his researches on alloys, finds that tom-toms and cymbals are made of bronze that can be worked cold the same as iron or aluminium bronze. The best tone is produced by an alloy composed of 78 parts of copper and 22 parts of tin.

Iridium, used as a coloring matter for glass and porcelain, gives a tint of intense blackness.

THE STRUCTURAL UTILITY OF IRON.

From "The Builder."

Recent incidents cannot fail to awaken a certain degree of interest in architectural and engineering circles, apart from that which is associated with the fracture of the Holborn Viaduct columns. In accordance with the conclusions of those whose opinion in such matters is regarded as deserving every attention, it would appear that the perishable nature and properties of iron as employed in static engineering no longer forms the principal object to be considered in reference to its utility or value as a building material. The decay to which iron is exposed from atmospheric changes and by variations of temperature has long been within the knowledge of many, and more recently the transitional qualities which iron and steel have been observed to possess, have attracted more general recognition. The molecular aggregation and dissociation of iron have been demonstrated to such a point of clearness that the material may be said to be capable of being held in atmospheric tension more eminently, perhaps, than any other substance employed in building. In addition to this circumstance, the molecular capacity of iron is known to be such as to admit of essential changes of its properties and functions. The same bar of material would, in accordance with the varying conditions of its employment, exhibit all the features and elements of new and distinct substances. The freedom of motion to which the constituent elements of iron and steel are known to be susceptible admits of the presentation of various orders or classes of fracture in the same sample, and the nature of such fractures may be said to determine the practical limits of the adaptation of iron as one among the materials of construction.

The sudden fracture of railway-carriage axles is sometimes attributed to a change effected in the material by vibration. After subjection to vibratory tests, a bar of fibrous iron has been observed to have completely changed, presenting a granular or crystalline fracture, it may be ; and it is eqally possible that a crystalline or granular sample should, under certain conditions, acquire the properties and features of a fibrous specimen. The singular atrophy, or withering away, to which iron, under some circumstances, is liable, and of which a familiar instance may have been noted on the part of many at the base as well as in other parts of iron railings, may readily suggest itself. Although an incident probably in a measure now obviated, and comparatively of but little moment, such exhibitions, notwithstanding that they may be said to be capable of being effectually remedied, invite special observation on the part of those who may be led to widely adopt the employment of iron in construction.

It might be unavailing, if not altogether devoid of interest, to single out the more trivial and fortuitous examples of the speedy decay to which the material under consideration is occasionally seen to arrive, but the total and intrinsic degeneration of such a substance by its mere proximity to others, whatever the process through which such a result is reached, is a subject possessed of unequivocal claims to investigation. In alluding thus prominently, it may be viewed by some, to what may be open to be regarded as the more unfavorable elements of this question, we would be understood as far from discountenancing the application of iron in a constructive direction. Many circumstances, however, we incline to think it would be agreed, contribute to indicate the necessity of some selection as to those conditions under which its employment would become more appropriate and effectual.

Upon the completion of many important erections in which iron is seen to have been largely employed, it is by no means an infrequent occurrence to observe that opinions are in certain directions at once set in motion, to the detriment of the undertaking in many instances, it may be gratuitously, but in the general result uniting to diminish the assurance of the public with reference to the stability or safety of such structures.

It has upon some occasions unhappily proved too well founded that substantial grounds may have existed for some amongst the numerous deductions to which these speculations are likely to lead, while in other instances the conclusions

which have been derived have been altogether disproved or shown to have been unfairly or unduly exaggerated.

It is a matter confessedly of such difficulty, even in the engineering circles, to assume an unconditional responsibility with reference to some of the reputed properties of iron, that a tendency has declared itself on the part of those more intimately interested in that science in connection with which its structural use is so closely associated, to endeavor to discover continually improving and more favorable modes of its application.

It is this latter view of the subject probably which may be considered to possess more special claims to the notice of our readers, nor should it be omitted to be conceded that in entering into a more critical examination of what few would probably treat as altogether unimportant, the modest pretensions which have been put forward on the part of the engineering profession are calculated to invite considerable forbearance, and may happily induce the supposition that the authority which age and experience can alone impart to the principles of any art or science may be expected to operate in its favor as it has done in many analogous instances.

Perhaps the most complete and authoritative inquiry which has yet been made with reference to the utility of iron for purposes of construction, is that which was instituted some twenty years ago before the committee for inquiring into the application of iron to railways. Since the time at which those investigations were conducted, the theory of the structural utility of iron has sought to embrace such conditions, and the process of the manufacture of that material have undergone such modifications, that in the future interests of architectural, no less than engineering science, it would appear far from undesirable that some similar inquiry should now be established.

The important experiments upon the properties of iron and steel which we owe to Mr. Kirkaldy, and to which we had occasion to allude in a notice of Mr. Bindon Stoney's lately-issued work "On the Theory of Strains in Girders and similar Structures," would almost of themselves suggest the wisdom of further legislative inquiry; for while manufacturers and public alike may appeal, in a certain measure, to the results of such experiments as likely to exercise a salutary check over the constructive application of the materials in question, it is the result of a purely voluntary and promiscuous system.

It may be fairly questionable whether the subjection, say, of the whole series of links of a suspension bridge to a fixed and arbitrary strain, is calculated to enhance the stability of such structures when erected.

Mr. Stoney, in stating that the functions and properties of iron become changed after its subjection to various strains, has recorded what has long been known perhaps in a less determinate form. Whatever may chance to constitute those obscurer qualities in iron and steel to which attention is attracted upon the occurrence of unexpected ruptures or disasters through the employment of those materials, it is obvious that they appear calculated to afford important constructive facilities, and will always invite employment in some building capacity. It is of practical moment, therefore, to the architect to seek to bring under more critical examination the occasions of failure in either of those materials in their structural application. The fall of the Manchester Station roof, some two or three years ago, it may be remembered, was attributed to a flaw in some portion of the casting; while the more recent instance of the Caledonian Station has been laid to the account of a tie-bar giving way; and in the case of the Ludgate-hill Station, the accident was referred to the simple misplacement of a strut.

It is with no intention of imparting an undue importance to such incidents that we make reference to occurrences some two or three years old; but the integrity of an extensive undertaking, it may be in iron, has been so frequently traced to, and imperilled by, the giving way of some trivial support, or member of the general structure, that the circumstances may demand pointed observation in any further inquiries into the strength and adaptation of such materials. In reference to novel discoveries in static engineering and attempted improvements in the application of the materials with which that science is identified, it cannot but afford matter of congratulation to notice any instances where it may have been more clearly shown that undoubtedly successful results have been attained.

Although the extraneous successes of certain engineering experiments may be said to possess less interest in architectural circles than where it has been sought to import similar endeavors into the domain of architecture, it must necessarily be of interest to note those claims which are occasionally alleged upon special grounds, with reference to the allied arts of construction. Apart from the employment of iron, so obviously has the theory of engineering been necessarily founded upon certain of the principles of architecture, that a sense of usurpation reigns in engineering circles wherever the distinctive element is more notably absent; and this it is which, in the opinion of some, might be held to shed light upon the assertion of an eminent member of the profession, that it has been very unsatisfactory to attempt to describe in a few general words what a civil engineer really is.

As an illustration of the more unfixed elements upon which the art of construction in iron is yet based, reference might be made to the evidence which was given by Mr. Robert Stephenson before the Committee of Inquiry, upon the application of iron to railway structures. The report of this Commission is known to be still regarded as of high authority in engineering practice, and the circumstance may be noted with all the more pleasure, as instancing the undoubted progress which has been made since the time of the inquiry in the profession to which it relates.

Upon being asked as to his opinion with regard to suspension-bridges, and whether he considered them at all applicable to railways, Mr. Stephenson replied: "To a very small extent. I do not think, with the prospect of our weights increasing upon railways, that you can run a locomotive over any chain-bridge in existence."

We have already had occasion to advert to the opinions which have been derived by Mr. Edwin Clark as to the construction of suspension-bridges, wherein he expresses his belief that the erection of a suspension-bridge sufficiently rigid for the purposes of locomotive traffic would be tantamount to the construction of a tube. Mr. Peter Barlow, whose experience in the structural application of iron entitles his opinion to great weight, is at issue with Mr. Clark, and remarks that, "although unsupported by fact or experiment, Mr. Edwin Clark's theory has been received and acted upon, not only by a large portion of the public, whose impressions of suspension-bridges are derived from what had hitherto been constructed of insufficient strength and without being combined with a girder, but it it had been received and acted upon by engineers of eminence in this country."

In the inquiry before the Commission to which we have alluded, an important exception was taken by Mr. Stephenson in favor of a system of suspension-bridge which at that time attracted considerable notice. The discovery invited such attention that Lord Western was induced to communicate at great length with Viscount Melbourne as to the superior applicability of the system to the repair or renewal of the Menai Bridge, deducing from actual experiments its merits in bridges of large span. This class of structure is known as Dredge's Patent Taper Suspension Bridge. Lord Western observed that the inventor insisted on the possibility of reconstructing the ironwork of the Menai Bridge at a less sum than the superfluous iron would sell for, pledging himself to the power of the bridge if the irons were altogether altered, using Lord Western's words, and reconstructed on his principle, to be capable of supporting on transit 1,000 tons.

The main principles of the Dredge suspension-bridge would seem to be comprised in the employment of pyramidal suspension-chains, and the substitution of oblique for vertical rods for connecting the suspension-chains with the roadway. The invention of Mr. Dredge, with reference to the application of iron in the erection of bridges more particularly, was supposed to embody such important structural principles, that, apart from the exception which was made in its favor before the Commission to which we have referred, it may now upon various grounds be found to possess further claims to practical consideration.

The Dredge principle is stated to have been founded upon the view that bridges are only brackets, and should be dependent upon their bases or abutments, and the strength of the material of which they are constructed, like the human arm, which depends on the shoulders, and not

on the fingers' ends—or the limb of the oak, which is sustained by the larger part of the branch that grows from the tree, and not by the ends of the twigs at its farthest projection. Bridges have hitherto been made to rest on their centres, as beams in architecture, and hence the superfluous material in them, with the immense accumulation of leverage that exists on their centres, is the cause of their undulation and destruction. In a common bridge, whose depth is one-twentieth of its length, and the weight 1,000 tons, the central forces are computed at 5,000 tons, instead of which no description of force or weight, according to the Dredge principle, should exist on the centre of the arch of any bridge, for it is but the extremity of two projections. The operation of the system is therefore in the direction of the annihilation of these static forces, which of themselves tend to destroy the structure, and to counteract which an excessive quantity of material must necessarily be employed, in accordance with more usual practices. One of the more important elements in connection with the erection of all suspension structures of the nature in view, has been the acquisition, at the least cost, of the maximum rigidity. and to accomplish this, various experiments have been suggested and employed. In the original suspension-bridge which existed at Hungerford Pier, in the line of the present Charing-cross railway, the lateral motion, as well as the deflection of that structure under passing and unequal loads was remarkable. In that case, as in the present Hammersmith and Chelsea bridges, the roadway was attached to supporting chains by vertical rods; but in the substitution of oblique bars in the Dredge system, considerable rigidity was supposed to have resulted. A more special treatment of this element of bridge construction may be noted in Koch's system of suspension, a class of structure perhaps deserving of fuller notice than it has yet received; but the more conspicuous instance is that to be observed in the stiffening which has been imparted to the Niagara Railway Bridge, by means of timber trussing following up the direction of the chains. This feature has been reproduced in Lambeth Bridge, iron being there, however, substituted by Mr. Barlow for the timber, as employed in the Roebling system. In most of the instances which we call to mind, the metallic section of the supporting-chains has been uniform at any point along the span, nor do we remember any case of such singular deviation from this principle as that to be noted in the pyramidal chain-bridge. The attempted economy of material towards the centre of lattice girder bridges may faintly shadow out the principle involved, and we cannot resist the impression that an exaggerated view has been taken as to the possible saving of material as between the Dredge principle of suspension and others. Perhaps the most exquisite adaptation of iron to structural purposes—that is, in a useful sense—to which we may refer, is instanced in the case of the London, Chatham, and Dover Railway Bridge, erected at the crossing of the Thames at Blackfriars; but it seems unhappily possessed of fewer lasting elements than its present neighboring structures.

The results of the experiments which were communicated by Lord Western to Lord Melbourne, upon the distinctive features of the Dredge bridge, would appear well calculated to attract the attention of the scientific; but, as we have before had occasion to notice, the extreme divergence of views entertained by the more eminent professors of engineering detracts from the value or importance, in a measure, of individual conclusions. Whether greater triumphs may be derived from the application of wire cables, assisted by vertical and horizontal trussing by the system of pyramidal chains and oblique suspension-bars, or by the tubular system conjoined with chains, or in the form of tunnels, we would be indisposed at this moment to venture to predict; meanwhile attention is being attracted to more recent discoveries as to the structural application of iron and steel. Out of the mass of conflicting and antagonistic evidence with which the theory of engineering is obviously beset, it would afford matter of congratulation should some settled principles be evolved, and it is because we incline to the view that at length some tendency in this direction may be detected, that we would seek to bring under notice some few of the more striking features of that art.

KANSAS has now more than 2,000 miles of railway.

ON SOME RECENT IMPROVEMENTS IN PISTONS.

From "The Engineer."

In pistons of many descriptions at present in extensive use, metallic or other packing is employed, and frequently in such manner as often to require adjustment by screws or other means provided for that purpose, which adjustment, besides requiring great skill and extreme care, must be always more or less uncertain, and consequently unsatisfactory, as the workman performing the operation under ordinary circumstances has no reliable indication of the extent of compression of the packing. The result often is that pistons are at first starting, so tightly packed as to cause great waste of power by friction, besides occasioning rapid wear of the piston and cylinder, so that leakage quickly follows, thereby necessitating the repacking of the piston at frequent intervals, an operation which usually involves considerable expense and loss of time.

Another description of packing in very common use is the ordinary plain cast-iron ring, which is likewise open to the objection that on being first put in, it presses to a greater extent against the cylinder's surface than is the case after working for some little time, besides which, its pressure does not vary in proportion to that of the steam upon the piston's side; consequently there is great loss by friction at first, and subsequently by leakage arising from excessive wear.

Now Messrs. Quick and Sampson obviate these serious evils by the employment of a novel and simple method, invented by them for causing the ring or rings of the piston to press constantly against the inner surface of the cylinder with a force which shall vary in proportion to the extent of variation between the pressures on the respective sides of the picton, the packing being so adjusted as to form a good but not unnecessarily tight joint at a minimum pressure, to force the piston ring or rings more and more tightly against the inner surface of the cylinder as the pressure upon the side of the piston increases, and to correspondingly reduce the force with which the ring or rings so presses or press against the cylinder in proportion as the pressure against the piston's side diminishes; and they attain these results without the direct action of the steam or other actuating fluid behind the packing rings. For these purposes the block or body of the piston is formed with small holes or passages, the number of which may be varied to suit the size of the piston, and these small holes or passages are fitted with corresponding small pistons properly packed and capable of moving therein when influenced by any excess of pressure at one side of the piston over that at the other side. The apparatus is so arranged that in the normal position of these small pistons—that is, when there is an equal pressure on both sides of the main piston—the latter will lie or move perfectly easy within the cylinder, but that any change in pressure on the respective sides of the piston will cause the small pistons to move endwise within their respective holes or passages in the block or body of the main piston, and such movement of the small pistons will be communicated from them through the cap, top plate, or junk ring of the main piston, or through suitable L pieces or equivalent devices, to the packing ring or rings, so as to force the latter against the inner surface of the cylinder.

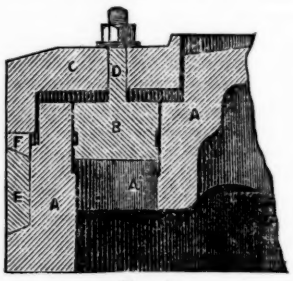


FIG. 1.

Fig. 1 represents a tranverse section, and Fig. 2 a plan (to a reduced scale) of part of a 55 in. piston which has been working constantly for upwards of twelve months in a single-acting pumping engine at the Southwark and Vauxhall Waterworks at Battersea.

A is the block or body of the piston; it is formed with three holes or passages A^1, provided with small pistons B, $3\frac{1}{2}$ in. in diameter, which work therein, and are

made to fit accurately by means of packing springs. The pistons B are connected to the junk ring C by small stems D, and nuts, as shown; E is the packing ring, whose edges are bevelled, and F is an intermediate ring having only its lower edge bevelled.

The bevelled surfaces of the rings E and F and lower part of the packing recess are ground so as to fit one another accurately. Any excess of pressure on the upper side of the piston has the effect of causing the junk ring C to press against the intermediate ring F, thereby forcing the bevelled packing ring E against the inner surface of the cylinder by compressing it between the bevelled surfaces of the block A and intermediate ring F.

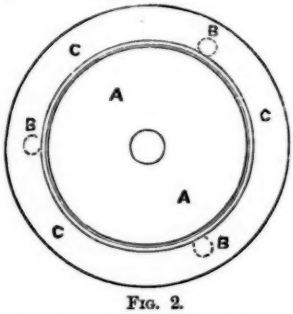


FIG. 2.

The piston previously used in this engine had a cast-iron ring packed up by india-rubber interposed between itself and the block of the piston, the india-rubber being compressed by the junk or cap ring. The result of the application of the improved piston in this case has been a reduction in friction during the down stroke equivalent to a steam pressure of one pound per square inch; while the relief afforded to the piston during the up stroke has resulted in an absolute gain of 10 ft. in the height to which the water is raised.

The old piston had to be looked at and repacked two or three times a year, and required a considerable quantity of grease, whereas the new one, after having run for upwards of twelve months without being inspected, was found to be in a very satisfactory condition, besides which the use of grease has been entirely discontinued. Fig. 3 represents part of a 70 in. piston applied to a direct-acting pumping engine at the Grand Junction Waterworks, Kew, working at an average steam pressure of 20 lbs. per square inch. This arrangement may also be applied with great advantage to double-acting condensing pumping or marine engines. A is the block of the piston, it is formed with four holes to receive four small pistons B, each 4 in. in diameter, which are connected by stems D, and nuts, to the junk ring C, as shown. The block A is furthermore formed to receive L pieces

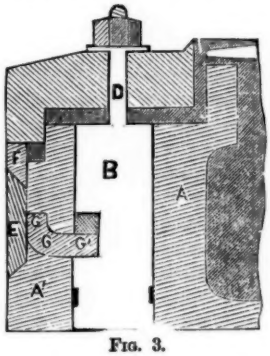


FIG. 3.

G, whose ends G^1 take in recesses formed in the sides of the small pistons B. When the pressure of the steam is on the under side, the small pistons B act against the ends G^1 of the L pieces, and cause their edges G to describe the arc of a circle, and so to force the packing ring E against the interior of the cylinder; but when (in double-acting engines) the steam pressure is against the upper part of the piston, then the junk ring C presses against the intermediate ring F, so that the bevelled packing ring E is forced against the interior of the cylinder by being compressed between the bevelled surfaces of the block A and intermediate ring F.

The following report, dated Feb. 12th, 1870, is from Mr. Alexander Fraser, engineer to the Grand Junction Waterworks. He says:—

"With respect to the patent piston which we have had fitted to the 70 in. direct-acting engine at our Kew Works, I am happy to say that it is a decided success. Since its introduction we have been able to dispense with a ton weight on the loaded plunger, showing a reduction in friction of over 5 per cent.; and whereas the former packed piston required 4 lbs. to 5 lbs. of tallow per day, the new piston requires almost none at all. There is a saving on this head of

quite £30 per annum, besides other advantages due to the absence of tallow in the cylinder. I shall certainly advocate the introduction of the new piston in the other engines at our different works, as opportunities occur for removing the present pistons."

A piston of the same construction as that referred to in Mr. Fraser's report has just been supplied to the Portsmouth Waterworks Company for a double-acting engine. Fig. 4 represents to a larger scale

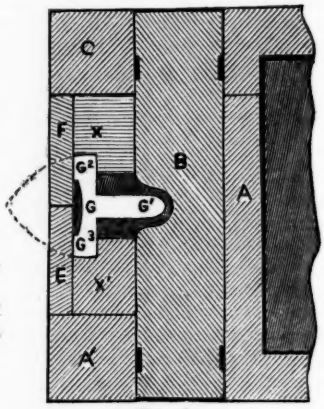


FIG. 4.

part of one of the improved pistons of 10 in. in diameter as applied with very satisfactory results to high-pressure double-acting engines at the Southwark and Vauxhall Waterworks, Battersea, and elsewhere. This arrangement of piston is suitable also for locomotives and other classes of high-pressure double-acting engines. A is the block or body of the piston; it is made with three holes or passages fitted with corresponding pistons B, each 1½ in. in diameter. These pistons pass through suitable holes formed for that purpose in the cap-ring C, which is in this case fixed to the block or body A of the piston by means of bolts; F and E are the packing rings. They are kept pressed against the interior of the cylinder by means of the T pieces G which are fitted into the block A; the ends G^1 of these T pieces pass through holes in the block A, and are let into recesses in the sides of the small pistons B. These recesses are of sufficient size to allow for the necessary motion of the T pieces when actuated by the movement of the small pistons, and for the same reason the edges G^2, G^3 of the T pieces are slightly bevelled. It will be evident that when the pressure of the steam is on the upper side the small pistons act against the ends G^1 of the T pieces, and cause their edges G^2 to describe the arc of a circle whose centre is at X, as shown dotted, and thus to force the lower packing ring E against the interior of the cylinder; and that when the pressure is on the under side the edges G^3 of the T pieces are caused in like manner to describe the arc of a circle having its centre at X^1, so as in turn to force the upper packing ring F against the interior of the cylinder to form the joint.

In a report referring to one of these pistons, Mr. Anderson of the eminent firm of Easton, Amos & Anderson, says:—"The patent piston has been in our foundry engine for a fortnight now, and to-day I had the cover taken off the cylinder and examined it. The engine is horizontal, and runs from 120 to 150 revolutions per minute under 50 lbs. steam. I had the flywheel scotched, and turned the steam full on the piston on the side opposite that from which the cover was removed. I found the cylinder very nicely polished, no trace of scoring anywhere, and the quantity of steam passing very insignificant considering the fact that the cylinder had run four or five years with another piston and had worn oval in the middle.

At the Battersea works of the Southwark and Vauxhall Waterworks Company a piston similar to that referred to in Mr. Anderson's report has been in constant use for about nine months.

During that time it has been examined twice, and was on both occasions found to be in first-rate order. It was put in to supersede a piston with a metallic ring, kept up by metallic springs, which, however, were a source of constant trouble and expense. It may not be out of place here to remark that the duty required to be done by the engines at such establishments as the Battersea Waterworks is of a character which imperatively demands the utmost regularity of action, and therefore that any appliance which is found to satisfactorily fulfil the requirements of such a situation (as Messrs. Quick and Sampson's piston has done) must, as a natural consequence, be one upon whose actual performance of its duty the most complete reliance can be placed.

THE FORECASTING OF STORMS.

Extract from an article by L. A. ROBERTS in the "Western Monthly."

It cannot be denied, that the complicated and constantly varying phenomena of that fickle entity which we denominate the Weather form a problem which in the nature of things must be extremely difficult of solution; and it is hardly probable that any man will ever be able in this field of inquiry to reach the same satisfactory results that have rewarded the labors of the astronomer. It is a source of legitimate pride to Americans, however, that in two important departments of meteorological investigation citizens of this country hold the first rank. To Dr. Franklin belongs the honor of discovering and elucidating the principles of electricity, and of demonstrating the influence of that subtle force upon the earth and its atmosphere; and it was Redfield who, something like a century later, deduced from his own careful observations of storms upon our Atlantic coast the important generalization that there is a class of great storms which originate near the equator, in the region of the West Indies, and rapidly advance, according to a fixed law, with a simultaneously gyratory and progressive motion, upon a well-defined curved axis toward the north pole. These storms vary greatly in intensity and in breadth—sometimes being confined to a narrow belt upon or a little way off from the coast, and again extending over a wide expanse of land and sea; but that they uniformly follow the same general course indicated by Redfield has been abundantly established by a great number of subsequent observations. It is not designed here to enter into an elucidation of this important law, but attention is called to it as marking one of the few real and tangible and practical achievements in the field of meteorological science. Its discovery and announcement stimulated investigators both here and in the Old World to renewed energy in their efforts to unravel the mysteries of atmospheric phenomena. The subject of storms, both ocean and inland, was especially studied with quickened zeal and enthusiasm; and in due course of time an attempt was made abroad—first in England, then in France, and afterward in other continental countries—to utilize the knowledge gained thereby in the interests of commerce, which, ever since it has existed, has been subjected to constant peril and loss from the effects of storms. The prevailing courses of the most destructive storms in various localities having been definitely ascertained, measures have been taken to give warning to exposed points of their approach, by means of the telegraph. This intelligence being promptly communicated by preconcerted signals to all vessels passing within sight of the shore or lying at anchor in harbor or roadstead, such vessels are enabled to take all necessary precautions against disaster before the storm shall burst upon them; and immense damage to shipping has thus in very many instances been avoided.

Notwithstanding the salutary operation of this system abroad, however, and notwithstanding the peril from storms to which our commerce on the great lakes and the Atlantic seaboard is constantly exposed, no measures have been taken in this country, until within the past few months, for the inauguration of such a system here. Early in the present session of Congress, however, the matter was brought to the attention of the House of Representatives by Hon. Halbert E. Paine, of Wisconsin, who offered in that body a joint resolution providing "for taking meteorological observations at the military stations and other points in the interior of the continent, and for giving notice on the northern lakes and seaboard of the approach and force of storms." The resolution in full is as follows:

"*Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled,* That the Secretary of War be, and he hereby is, authorized and required to provide for taking meteorological observations at the military stations in the interior of the continent, and at other points in the States and Territories of the United States, and for giving notice on the northern lakes and on the sea-coast, by magnetic telegraph and marine signals, of the approach and force of storms."

This resolution was promptly passed by both houses of Congress, and on the 9th of February, 1870, became a law by

the approval of the President. By General Orders No. 29 from the headquarters of the army, dated March 15, 1870, the chief signal officer of the army, Brevet Brigadier-General A. J. Myer, is charged, subject to the direction of the Secretary of War, with the execution of the provisions of this enactment, and all commanding officers are enjoined to afford every facility for the successful prosecution of the undertaking; while scientific establishments, commercial associations, and others, are requested to aid, by their co-operation, in the accomplishment of the work.

Professor J. A. Lapham, of Milwaukee, impressed by the frightful aggregate of a single year's disasters to vessels on the great lakes—amounting for the year 1869 to the immense number of 1,914, with an estimated damage to property of over four millions of dollars—was perhaps the first to suggest some action by Government for inaugurating such a system of storm-reporting as, through the efforts of General Paine, has now happily been adopted. It should be remarked that by no means all of the disasters included in the aggregate above given were of that class which might have been obviated by the operation of the system we are considering. Very many were due to imperfect machinery, defective boilers, careless collisions, conflagrations, and other causes. Yet, making all proper deductions on this score, enough remain to be attributed to the destructive force of severe and unheralded storms, to fully justify any action by Government looking to a mitigation of the destruction of property and the peril and often loss of life which they entail. No corresponding statistics are at hand as to the yearly disasters upon our Atlantic seaboard; but these are very numerous, as is well known, and of these a much larger proportion than of the lake disasters are attributable to the agency of storms. Besides the great equatorial storms already alluded to, which in their course toward the pole follow approximately the coast line of the United States, our coasting vessels are likewise exposed to frequently-recurring tempests, especially in the summer season, which originate probably upon the great desert basin in the interior of the continent, and, sweeping eastwardly across the Mississippi Valley and the great lakes, expend their final fury upon the ocean and its navigators.

Nor must we overlook the damage often worked on land, as well as upon the water, by these latter storms, and by those tornadoes of narrower limit and shorter duration, but often of even greater intensity, which prevail at intervals throughout the Mississippi Valley and lay waste the narrow belt of country which they traverse. Of this class was a storm which swept through Northern Ohio and on the Alleghany Mountains in Pennsylvania in the summer of 1855, demolishing very many buildings in its course, uprooting trees and razing fences, and causing the death of many persons. So furious was this storm, and yet of so limited a breadth—only about an eighth of a mile—that while in some villages over which it passed scarcely a house escaped damage, in others only the northern or southern section of the town would be devastated; the outer verge of the destructive force being so sharply defined that while one house, that fell within its track, would be almost totally destroyed, another, but a few yards distant, would be wholly unharmed. The course of this storm may even yet be easily traced in the forests through which it raged. It cut a clean swath as it went, leaving openings that look as if they had been cleared for a highway or a railroad. The timber thus prostrated was in some cases utilized for firewood or for lumber; but in many places the trunks of the trees were left in such inextricable confusion and tangle—having fallen in every conceivable direction, and being in some instances individually twisted into splinters, as a result of the rotary action of the storm—that it was found inexpedient, in a country where timber was plenty, to attempt to "pick up the pieces;" and thus the logs were left to rot and replenish the earth. And now, throughout these storm-openings in the woods, vast thickets of the highbush blackberry have grown up; and so we have, as the latest result of that furious tempest, an almost unlimited abundance yearly of the finest blackberries anywhere to be found.

No one who has witnessed such a storm as this will ever forget it. The imminent peril of a storm at sea may be greater and more appalling; but nothing can be more exciting than one of these fierce whirling tornadoes, accompanied,

as they almost always are, by a deluge of rain and an almost constant rolling of thunder and glare of lightning. The storm is heralded by a heavy mass of cloud in the west or southwest, dark, with a sulphurous tinge, over the face of which there is an almost constant play of lightning, and within which an ominous muttering of thunder. Then there is a dash of rain, a moaning of the wind, and the next moment the storm bursts upon you. Then the air is full of a tumult of unwonted sounds. Loose shutters, sign-boards, and what not, are dashed against the house. Chimneys are blown into individual bricks, and the bricks come clattering down the flues. Doors and windows are burst open; the house shudders to its foundations; and the next moment you behold your roof following your neighbor's in a wild flight for the open country—going to pieces as it is borne along like a wreck upon the sea—scattering its fragments broadcast, some of them being found afterwards miles away. Such unfortunate persons as chance to be abroad upon the streets when the fury of the tempest is let loose, strive in vain to make headway either with or against the current, and can do no better when blown to the ground than lie prone there and thank their stars if nothing more pitiless than the drenching rain shall fall upon them; for factory chimneys and church spires go down like grass before the mower, and walls are falling on all hands. One poor man, seeking to rescue a span of valuable horses that are hitched to leeward of a house wall that he fears may fall, is too late; for even while he is in the act of untying the halter the wall is down, crushing the horses and burying himself to the middle in its *debris*,—and there he stands, upright, stark dead in an instant! A little farther down the street an unfinished frame building goes down even before the workmen upon it can reach the ground, and three men are crushed in the mass of timbers and escape death by a miracle.

All this, and vastly more, in one little village; and a dozen villages are in the track of the monster. Aye, a monster he is, and almost insatiable, but not quite; for right in his course stands a little country-house, the inmates of which, looking westward, hear his roar and see him come crashing through a belt of woods a quarter of a mile away. They make such hasty preparations as they can for the impending catastrophe; but, to their utter astonishment, they find in a minute or so that the storm has passed them by unharmed and is tearing through the woods to the east of them. This characteristic of these tempests has been often observed. While in general they move upon the ground, sweeping it clean as they go, occasionally they rise above it, and again descend—bounding, as it were, like an india-rubber ball that has received a superior ground stroke from the champion batter of a "first-nine."

Perhaps the most terrible storm of this character that ever occurred in the United States was that which destroyed the villages of Comanche, Iowa, and Albany, Illinois, situated upon opposite sides of the Mississippi, on the evening of June 3d, 1860. This fearful storm will long be remembered by all persons who resided at the time of its occurrence anywhere in the region through which it passed. It commenced as two separate and distinct tornadoes, which, moving eastwardly in well-defined and nearly parallel courses, crossed Cedar River in Iowa 12 miles apart, and then gradually converged, until, at a point about 25 miles west of the Mississippi, they united, and thence advanced in a single column with indescribable fury. After crossing the Mississippi, the force of the storm gradually diminished, and it had subsided into a mild gale by the time it reached Lake Michigan. In this tornado one hundred and thirty-four lives were reported to have been lost west of the Mississippi alone, and over two thousand persons were by its ravages rendered homeless. A gentleman who witnessed the storm at the point of its greatest intensity, describes it as looking, when first observed, "merely like a threatening cloud; but it soon assumed the appearance of a huge serpent, extending from the clouds to the earth, and twisting and writhing with an undulating motion, accompanied by a roaring more terrible than that of the mightiest cataract."

Tornadoes like these, though generally somewhat less intense and destructive than these, prevail every season, and rage with no less fury upon the lakes than upon the land; and as they move almost uniformerly from west to east, or from south-

west to north-east, and at a rate of speed ranging generally from 20 to 40 miles an hour, there would seem to be no reason why such a system of storm-reporting as that just established by the Government should not be made immediately available in rendering invaluable service to our lake commerce. As to the entire practicability of the scheme there can be no question. General Myer, in a letter to General Paine upon the subject, quotes from the telegraphic news despatches in a single issue of a Washington newspaper a series of reports from different points in the West and Southwest, which together map out clearly the course and rate of progress of a storm of wind and rain that prevailed throughout a wide extent of territory in January last. These reports were made without any concert or system, of course, but show conclusively that valuable practical results may be easily attained through intelligent concert and system. Here are the different despatches:

"St Louis, *January* 17.—A terrible storm of thunder and lightning, wind and hail, passed over the city last evening."

"Chicago, *January* 17.—During the thunder-storm last night the mercury stood at 42 deg."

"Louisville, *January* 17.—A terrible tornado visited Cave City Station, on the Louisville and Nashville Railroad, at an early hour this morning."

"Cincinnati, *January* 17.—An unusually heavy storm of wind and hail, accompanied with thunder and lightning, occurred here this morning."

"Pittsburgh, *January* 17.—A heavy rain storm, with thunder and lightning, visited this city at noon to-day."

There is no difficulty in deducing from these data the fact that on the evening of January 16th a storm prevailed at St. Louis, which, moving easterwardly over a broad belt of territory, reached Chicago some time during the same night, Cave City Station the next morning, Cincinnati later in the morning, and Pittsburgh at noon of the 17th,—having traversed the distance from St. Louis to Pittsburgh in some 18 hours or at the rate of about 30 miles per hour. From the newspapers of the following day it might have been quite as easy to trace the storm on to the seacoast, and perhaps to gather particulars of the damage to shipping which it caused.

For several years the Smithsonian Institution has been collecting meteorological observations from all parts of the country, and laboring to deduce from the facts thus gathered the laws governing the phenomena of the weather and the climate; and the valuable results so gained can now be drawn upon in inaugurating the new system of storm-prediction and reporting. "The determination of the full details of this system will be arrived at," says General Myer in a communication to the Secretary of War, "only after careful study of the modes already tested in other countries, and consultation with experienced observers, telegraph companies, boards of commerce, and business men, as to their application or improvement in our own. There will need to be the study and determination of the points for observation; the supply of instruments, and the facilities for their use; the exact observations to be made; the exact form and times in which, when made, they are to be reported; the points at which reports are to be collected and deductions from them had; the places at which and the modes by which these deductions shall finally be announced, by telegraph and signal, and so made useful to the public, for the benefit of commerce, by the warning they may give or the aids they may offer. It is a wise provision of the act," he adds, "that it enables the army to be thus extensively utilized in the interest of commerce, by the exercise of duties already established, and which will require but additional outlay. It would be needless and unwise to enter upon large expenditures by attempting at the beginning too extended a scope for the endeavor. * * * I would suggest, therefore, that action under the resolution be limited, until the best modes for its execution shall have been wisely determined."

In accordance with this view, he asks for an appropriation for carrying out the law, of the modest sum of $15,000 for the current fiscal year, ending June 30, and $25,000 for the next fiscal year, ending June 30, 1871. As showing that the scheme is regarded with prompt favor by the interests it is designed to benefit, General Myer mentions the fact that the favorable proceedings upon the subject of six boards of commerce had, at the date

his communication, and within little more than a week after the approval of the joint resolution, been received at the office of the chief signal officer.

Professor Joseph Henry, of the Smithsonian Institution, writing to General Paine in approval of the objects of his joint resolution, points out the following conditions as essential to the success of the proposed system :

"1*st*. The points from which the telegrams are to be sent must be carefully selected and furnished with reliable instruments. 2*d*. These instruments must be in charge of persons properly trained to make the observations. 3*d*. The telegrams must be transmitted regularly to some central point at fixed hours of the day. 4*th*. They must at this centre be collated and their indications interpreted by persons having a competent knowledge of the laws to which the motions of the storms are subjected. 5*th*. I do not think the military posts as now established will be sufficient to fully carry out the plan ; additional stations would be required. 6*th*. An appropriation would be necessary for the pay of the telegrams, furnishing the instruments, and the necessary superintendence."

And Professor Elias Loomis, of Yale College, author of a valuable text-book upon Meteorology, writes to General Paine upon the same subject at length. He says :

"It is believed that our knowledge of storms is already sufficiently precise to enable a competent meteorologist to furnish information which would be of great value to commerce, provided he had at his command a sufficient corps of observers scattered over a considerable area to the west and south-west, and also had the means of transmitting his warnings immediately by telegraph ; and if such a system were pursued for several years, it could scarcely fail to conduce to more precise knowledge, which would render it possible to give more reliable and definite warning of the approach of dangerous storms.

"In order to secure the objects here contemplated, it would be indispensable to have observations from a pretty large number of stations at intervals not exceeding one or two hundred miles, and scattered over a region to the west and south-west of those points for which the warnings were regarded as specially important. These observations should include all the usual meteorological instruments, but more particularly the barometer, with the direction and force of the wind. The observations should be made daily at fixed hours, and should be reported by telegraph to some competent meteorologist, whose business it should be to compare the reports without delay, and make the proper deductions from them; and whenever a violent storm was in progress, to decide in what direction and with what velocity it was travelling; determine what places it would visit, and at what hour it would arrive ; and finally transmit the announcement immediately by telegraph to those places especially interested. Such a system could not be expected to attain satisfactory results without a pretty large number of well selected stations, and especially without the service of a competent meteorologist to superintend the entire system. The superintendent should be well informed respecting the progress which has been already made in this department of science ; he should have strong faith in the practicability of attaining useful results by a system of storm-warnings ; and he should have no other engagements which would prevent him from giving his whole attention to this subject, especially whenever a violent storm was raging in any part of the United States."

These coincident views of the two highest authorities in the United States upon all matters relating to meteorological science doubtless foreshadow substantially the actual working of the system when it shall have been fully established. In due time we may reasonably expect to see every light-house and other prominent and sightly point upon the borders of the great lakes and the Atlantic coast connected by telegraph with a central meteorological bureau, to which intelligence of an approaching storm can be simultaneously and speedily conveyed —to be in turn communicated, by means of a uniform system of signals, to all vessels within reach, in ample time to enable them to prepare for the coming danger.

That the results of the operation of this system will be in the highest degree valuable, both as regards the immediate practical object of protecting our commerce

from disaster, and as furnishing an aid to scientific investigation in a most important direction, there can be no reasonable doubt.

HEAT BY MEANS OF ILLUMINATING GAS.

From "Revue Industrielle."

"Gas as a combustible," said M. Cazin, at a recent scientific conference, "offers the best solution of the problem of distribution of motive power in large towns where the illumination by gas is already established. The pipes which furrow our cities convey a provision for light, for heat, and for motive force. We demanded primarily of the gas the first of these agents; we have demanded also the second; it is now time to demand of it all that it is capable of affording. Why should not the same apparatus afford to the workman in his shop light, heat, and power?

"When gas becomes cheaper this remarkable amelioration of the lot of the artisan will be realizable."

We will add that the obstacles to the employment of gas as a source of motive power arise not only from its high cost, but also from its disagreeable odor, and the absence of proper means for good combustion.

The odor which is produced chiefly at the commencement of the operation is produced by condensation of some of the products of the combustion upon a cold surface. It may be prevented in a great measure by previously heating the generator with another combustible.

With regard to an efficacious burner, we do not know of any; Bunsen burners, which are generally preferred, afford hardly one-half the calorific power contained in the gas.

The Parisian Company have directed a series of trials upon the calorific capacity of illuminating gas, which give sensibly the same results.

Copper tubular boilers were employed of a capacity of 10 to 30 litres. The heat was obtained from two Bunsen burners with flames from 20 to 25 centimetres high. The bottom of the boiler was placed so as to receive the flame at the height of 14 to 16 centimetres above the base.

The following table exhibits the results of the experiment:

Temperature of the Water.	Time of Heating.	Expenditure of Gas.	Gas used for each 10^2 of Heat.
Degrees.	Minutes.	Litres.	Litres.
10	..	..	..
35	10	160	64
60	15	188	78
80	15	191	95
90	7	100	100
100	7	100	100
	54	739	

The boiler weighed 6.5 kilogs.; it contained 29.5 kilogs. of water.

The number of calorific units produced was therefore $6.5 \times 9^* + 29.5 \times 90^\dagger = 2{,}713.5$. This corresponds to 3,700 units to the cubic metre of the gas.

The mouth of the Rhone is obstructed by a bar of sand, which renders it inaccessible to sea-going vessels. The Government has undertaken, with the assistance of the local authorities, the excavation of a canal which shall admit such vessels into the Rhone, behind the bar, from the Bay of Fos. This canal, named the canal St. Louis, begins at the back of the bar, near the deserted town of St. Louis (in the main branch of the river), and ends in the north-western end of the Bay of Fos, known as the "Anse du Repos," or Bight of Rest, from its peculiar advantages as a harbor of refuge. The western end of the new canal will be closed by a lock, and the eastern end will open into a spacious harbor. The works are progressing rapidly, and it is expected that they will be completed by next August. The depth at the end of the main branch is from 1½m. to 2½m.; at the entrace of the new harbor is the Bay of Fos; it is 8m.; equal to 26 ft.

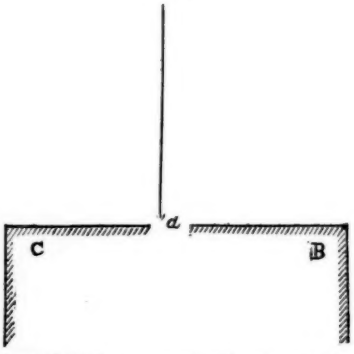
* Calorific capacity of the copper.
† Heat obtained from the gas.

FORMULÆ FOR STRAINS IN TRUSSES AND THEIR PRACTICAL APPLICATION.

By S. H. SHREVE, A. M, LL.B., Member of American Society of Civil Engineers.

Let *a* be the point of application of a weight or vertical force to be transferred to the two supports *B* and *C*. It is self-evident that this cannot be done without the aid of horizontal forces of sufficient amount to change its direction to *B* and *C;* for no increase or decrease of the force at *a* can change its direction. It is also

Fig. 1.



evident that the amount of horizontal force depends upon the amount of the vertical force. The latter in the case of a weight upon a girder resting upon two supports, without lessening its own amount, creates sufficient of the former to carry it to the supports and no more ; and as these two and their compounds are all the strains that can affect a girder, and as they are mutually dependent, it follows that from one of them, we can determine the other.

To do this we should use two well-known mechanical laws; that of the lever : "If a weight rest upon a beam supported at its extremities, the supports react with two upward pressures, whose sum is equal to the weight, and the proportion of the weight sustained by either support is to the whole weight as the remote segment is to the whole beam." No arrangement whatever of the truss can affect this law.

The other law is that of the equality of moments :

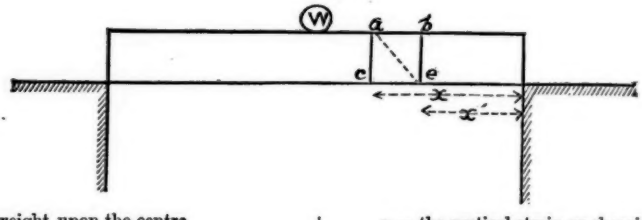
"If any number of pressures in the same plane be in equilibrium, and any point be taken in that plane from which their moments are measured, then the sum of the moments of these pressures which tend to turn the plane in one direction about that point, is equal to the sum of the moments which tend to turn it in the opposite direction."

The misapprehension of one of our authors renders it necessary to explain that the moment of a force referred to any point is the amount of the force multiplied by the distance perpendicular to the line of its direction.

All the cases which are investigated are those of girders or trusses with horizontal and parallel flanges or chords.

Case 1.—A girder supported at both ends and loaded at the centre only.

Fig. 2.



Let w = weight upon the centre.
l = the length of the girder.
d = the depth of the girder.
x = the distance of any point from one abutment.
x' = the distance of any other point from the same abutment.
H and H′ = the horizontal strains in either flange or chord at the points x and x'.
v = the vertical strain or shearing force not affecting either flange or chord.

The whole of the horizontal strain is supposed to be concentrated in the flanges at the points x and x', and the flanges receive no part of the vertical strain.

The moments around a point in the

lower flange of the girder directly under the weight are : the reaction of one abutment, $\frac{w}{2}$, multiplied by its distance from the point, $\frac{l}{2}$ or $\frac{w\,l}{4}$ in one direction ; and to resist it, the horizontal strain in the upper flange, H, multiplied by its distance from the point d; the horizontal strain in the lower flange and such vertical strain as there may be, pass through the point, and consequently have no moments.

Therefore $H\,d = \frac{w\,l}{4}$, or $H = \frac{w\,l}{4\,d}$ . . . (1)

In the same manner the strain in the lower flange can be shown to be of equal amount; but the latter is a strain of tension, while the former is one of compression.

Taking the moments around any other point in the lower flange, distant x from the same abutment as before, we have the reaction of the abutment, $\frac{w}{2} \times x$, its distance in one direction, and $H \times d$ to resist it, or

$$H = \frac{w\,x}{2\,d}, \qquad (2)$$

H in eq. (2) is less than the H of eq. (1), because x is less than $\frac{1}{2}$, or, the horizontal strain is greatest at the centre.

At any other point, x', between x and the abutment,

$$H' = \frac{w\,x'}{2\,d} \qquad (3)$$

H′ is less than H because x' is less than x,

Subtracting,

$$H - H' = \frac{w\,x}{2\,d} - \frac{w\,x'}{2\,d} = \frac{w}{2\,d}(x - x') \qquad (4)$$

An amount of horizontal force that has disappeared from the flange between H and H′ and consequently has passed into the web. This it is evident it could not do unless a vertical force be united with it.

In the figure, let $a\,e$ represent the direction of the force that contains the difference of the horizontal forces, or $H - H'$. If $a\,b$ represent this amount of horizontal force, $b\,e$ will represent the vertical component of $a\,e$ and therefore,

$$a\,b : b\,e, \text{ or } x - x' : d :: \frac{w}{2\,d}(x - x') : \frac{w}{2} \qquad (5)$$

or the vertical force at any point in a girder loaded at the centre is equal to half the weight and is independent of the length and depth ; and also of $x - x'$, which may be considered indefinitely small as in a girder with a continuous web.

These are all the strains that can affect this case :

A horizontal force, $H = \frac{w\,x}{2\,d}$, at any point distant x from the abutment, in either flange.

A vertical force, $V = \frac{w}{2}$, at any point in the web.

And where there is a diagonal, as in a truss, its strain is the resultant of $\frac{w}{2}$ vertical, and $\frac{w}{2\,d}(x - x')$ horizontal ; x and x' being the respective horizontal distances of the ends of the diagonal from the abutment. Or if i be the angle between the diagonals and a vertical, $\frac{w}{2}$ sec. i, is the strain in any diagonal.

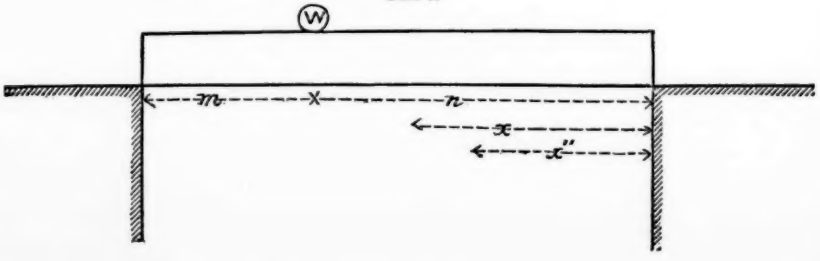
It will be seen from the above that the web conveys from one flange to the other an amount of horizontal force equal to the whole of that in either flange and in this manner one horizontal strain neutralizes the other.

As the horizontal force is only sufficient to carry the vertical force to the abutment, so the vertical force is only sufficient to neutralize the two horizontal strains by bringing them together.

Let the weight be moved nearer one abutment.

Case 2.

FIG. 3.



Let w = the weight.
m = the distance of the weight from the left abutment.
n = equal the distance of the weight from the right abutment.
$\frac{w}{l}n$ = the reaction of the right abutment by the principles of the lever.
$\frac{w}{l}n$ = the reaction of the left abutment.
l. d. x. H. V. as before.

Taking the moments as before around a point under the weight, we have

$$H \times d = \frac{w}{l} m \times n$$

and
$$H = \frac{w\,m\,n}{d\,l}. \qquad (6)$$

(In this and the subsequent cases, where not otherwise mentioned, x will be measured from the right abutment and the reaction of that abutment considered.)

At any point x,

$$H = \frac{w\,m\,x}{d\,l}, \qquad (7)$$

At x',

$$H' = \frac{w\,m\,x'}{d\,l}, \qquad (8)$$

Subtracting,

$$H - H' = \frac{w\,m}{d\,l}(x - x'), \quad (9)$$

Using the same proportion as before.

$$x - x' : d :: \frac{w\,m}{d\,l}(x - x') : \frac{w\,m}{l} \quad (10)$$

In the same manner the vertical force between the centre and the left abutment can be shown to equal $\frac{w\,n}{l}$,

Or, the vertical force, in a beam loaded at one point, between that point and either one of the abutments, is equal to the reaction of that abutment.

As in the first case, we have now all the strains that can affect this case.

Case 3. A girder supported at both ends and loaded uniformly.

Let w = weight of the whole load.
l. d. x. x'. H. H'. and V. be the same as before.
$x - x'$ is a constant quantity.
$u = \frac{x + x'}{2}$ or the distance from the same abutment from which x and x' are measured to a point midway between the two.

The moments around any point distant x from the right abutment, in the lower flange, are, the reaction of the abutment $= \frac{w}{2}$ multiplied by its distance x in one direction; and in the opposite the load on the part x, which is $\frac{w x}{l}$ multiplied by the distance of its centre of gravity from the point around which the moments are taken, which is $\frac{x}{2}$ and the horizontal strain in the upper flange H, multiplied by its distance d, whence

$$H\,d = \frac{w\,x}{2} - \frac{w\,x^2}{2\,l}, \text{ or } H = \frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,l} \quad (11)$$

This is the equation of the horizontal force in either flange of a uniformly loaded girder at any point distant x from the abutment.

If $x = 0$ or l, then $H = 0$.

If $x = \frac{l}{2}$; $H = \frac{w\,l}{8\,d}$, the horizontal strain at the centre.

In the same way

$$H' = \frac{w\,x'}{2\,d} - \frac{w\,x'^2}{2\,d\,l} \qquad (12)$$

As in the first case, $H - H'$ represents the horizontal force which has united with a vertical force and passed into the web. This vertical force can therefore be obtained as before, from the proportion $x - x' : d$.

Subtracting, we have

$$H - H' = \frac{w}{2\,d}(x - x') - \frac{w}{2\,d\,l}(x^2 - x'^2)$$

$$x - x' : d :: \frac{w}{2\,d}(x - x') - \frac{w}{2\,d\,l}(x - x')(x + x') :$$

$$\frac{w}{2} - \frac{w}{2\,l}(x + x') \qquad (13)$$

Since $u = \frac{x + x'}{2}$

$$V = \frac{w}{2} - \frac{w\,u}{l} \qquad (14)$$

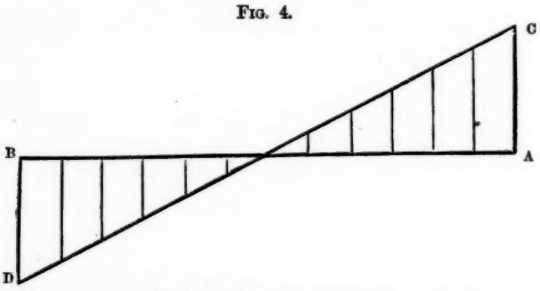
This is an equation giving the vertical strain at any point distant u from the abutment.

From eq. (14) it can be seen that the vertical force at any point is equal to half the weight less the weight between the point and the abutment.

This equation is entirely independent of d or the depth of the girder, and consequently is applicable to a rafter or an arch.

It is also the equation of a straight line as shown in the following figure, where the vertical force and the horizontal distance are the co-ordinates of any point in that line.

FIG. 4.



Let A be the origin; on the vertical axis make A C by a scale $= \frac{w}{2}$, and on the horizontal axis make A B $= l$, and D B $= \frac{w}{2}$ and join D C. The vertical lines will show the amount of vertical force at any point.

When $u = 0$, $V = \frac{w}{2}$,

If $u = l$, $V = -\frac{w}{2}$,

If $u = \frac{l}{2}$, $V = 0$.

When u becomes greater than $\frac{l}{2}$, V has the minus sign, showing that the weight at that point is carried to the other abutment. This is shown in the figure by the vertical lines below A B.

It is important to remember that the equation $V = \frac{w}{2} - \frac{w u}{l}$, is the same when u is measured from either abutment, that is if the equation be referred to either abutment; and when V has the + sign the vertical force is passing to the abutment from which u is measured; when the opposite sign, then to the opposite abutment.

The origin of the axes in Figure 5, can be changed to the centre by making $\frac{w}{2} = 0$.

Then $V = \frac{w u}{l}$, is the equation of the vertical force, u being measured from the centre to the right or left.

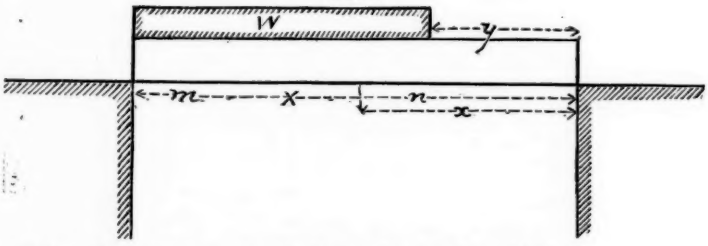
We have seen from the equations that the horizontal strain is the greatest at the centre and zero at the ends, and the vertical strain is greatest at the ends and zero at the centre.

If $x - x'$ be considered as indefinitely small, u may be considered equal to x, and the above statement can be proved by differentiating the horizontal equation and obtaining its maximum value, which will be found to be when $V = \frac{w}{2} - \frac{w x}{l} = 0$, or, when $x = \frac{l}{2}$.

Therefore, when either of these forces, the horizontal or the vertical, reaches its maximum the other becomes zero.

The point of greatest horizontal strain is the dividing line between the weights, where the load on either side passes to the abutment on that side. No vertical strain passes this point.

FIG. 5.



Case 4.—A partially loaded girder supported at both ends.

Let w = the weight.
m = half the length of the loaded part.
$n = l - m$.
y = the length of the unloaded part.
l, x, u, d, H, and V, as before.
$\frac{w}{l} m$ = the reaction of the right abutment.

$\frac{w}{l}n$ = the reaction of the left abutment.

The moments around a point in the lower flange distant x from the right abutment are, the moment of the right abutment $= \frac{w\,m\,x}{l}$ in one direction; the horizontal force H multiplied by d, and the moment of the load on

$$x-y = \frac{w}{2\,m}\,(x-y).\ \frac{x-y}{2}$$

in the opposite direction, whence

$$\mathrm{H}\,d = \frac{w\,m\,x}{l} - \frac{w}{4\,m}\,(x-y)^2.$$

And
$$\mathrm{H} = \frac{w\,m\,x}{d\,l} - \frac{w}{4\,d\,m}\,(x-y^2) \qquad (15)$$

This equation will assume the form of eq. (11), by making $y = o$ and $m = \frac{l}{2}$ which would be the case for a girder fully loaded.

For a point x' between x and the right abutment within the loaded part,

$$\mathrm{H}' = \frac{w\,m\,x'}{d\,l} - \frac{w}{4\,d\,m}\,(x'-y)^2 \qquad (16)$$

The difference

$$\mathrm{H}-\mathrm{H}' = \frac{w\,m}{d\,l}\,(x-x') - \frac{w}{4\,d\,m}\left\{x^2 - x'^2 - 2y\,(x-x')\right\} \qquad (17)$$

We again obtain the vertical force from the proportion $\frac{d}{x-x'}$, which gives

$$\mathrm{V} = \frac{w\,m}{l} - \frac{w}{4\,m}\left\{(x+x') - 2\,y\right\} \qquad (18)$$

putting
$$u = \frac{x+x'}{2}$$

$$\mathrm{V} = \frac{w\,m}{l} - \frac{w}{2\,m}\,(u-y) \qquad (19)$$

Or the vertical force in this case is equal to the weight borne by the abutment less the weight on the part $(u-y)$. If the partial load be a constant load the point of greatest horizontal strain is when

$$\mathrm{V} = \frac{w\,m}{l} - \frac{w}{2\,m}\,(u-y) = 0.$$

The vertical force can also be found from the reaction of the left abutment.

In the equation

$$\mathrm{V} = \frac{w\,m}{l} - \frac{w}{2\,m}\,(u \quad y)$$

V increases as u decreases until

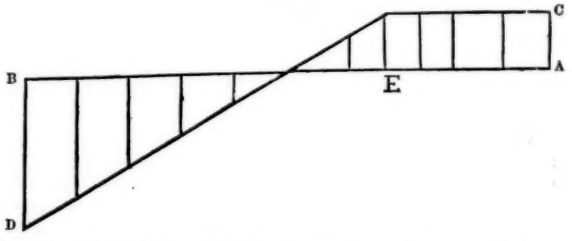
$$u = y, \text{ or } u-y = 0, \text{ when } \mathrm{V} = \frac{w\,m}{\cdot}$$

or the vertical force at the end of the load and between it and the abutment is equal to the reaction of the abutment.

$$\mathrm{V} = \frac{w\,m}{l} - \frac{w}{2\,m}\,(u-y)$$

can be represented as in Figure 6.

FIG. 6.



A B is the length of the girder, B D the weight borne by the left abutment, A C the weight upon the right abutment; B E the part of the girder covered by the load, the vertical lines representing the vertical strain at any point, those above A B have the + sign in the equation and pass to the right abutment; those below have the − sign and pass to the left abutment.

In the vertical equation

$$\mathrm{V} = \frac{w\,m}{l} - \frac{w}{2\,m}(u-y)$$

w represents the partial uniform load upon a girder and is consequently a variable. It is necessary often, to have the amount of the full load whose weight per foot is the same.

Let w' = full load.

Then w of the above equation $= \frac{w'}{l}\,(l-y)$

And $2\,m = l-y$,

Whence

$$\frac{w\,m}{l} - \frac{w}{2\,m}\,(u-y) = \frac{w'\,(l-y)^2}{2\,l^2} - \frac{w'}{l}\,(u-y). \qquad (20)$$

which is the equation of the vertical force at any point u under a uniform partial

load reaching to y where w' is the weight of a full load of the same density.

The greatest vertical strain at any point is when the girder is loaded from the abutment beyond the centre to that point.

For, let the load extend from the left abutment beyond the centre to a point distant u from the right abutment.

Then at the end of the load where $u = y$, eq. (20) becomes

$$V = \frac{w'(l-u)^2}{2\,l^2}, \qquad (21)$$

when

$$V = \frac{w'}{2} - \frac{w'\,u}{l} + \frac{w'\,u^2}{2\,l}. \qquad (22)$$

But at the same point under a full load (w') eq. (14).

$$V = \frac{w'}{2} - \frac{w'\,u}{l}.$$

Or, between the centre and the abutment, when the longer segment is loaded, the vertical strain is greater by the value of $\frac{w'\,u^2}{2\,l}$ than it is at the same point under a full load of equal weight per foot.

For example, under a full load the vertical strain at the centre is zero for $u = \frac{l}{2}$.

But when the girder is loaded to the centre $u = \frac{l}{2}$, and $V = \frac{w'}{8}$, or the vertical strain is one-eighth of a full load.

The equation of the horizontal strain under a partial load, where

w' = the weight of a full load of equal density.

y = the unloaded part.

x = any point under the load, is

$$H = \frac{w'\,(l-y)^2\,x}{2\,d\,l^2} - \frac{w'\,(x-y)^2}{2\,d\,l}, \qquad (23)$$

which reduces to the form,

$$H = \frac{w'\,x}{2\,d} - \frac{w'\,x^2}{2\,d\,l} - \frac{w'\,y^2}{2\,l}\left(1-\frac{x}{l}\right). \qquad (24)$$

Under a full load the strain at the same point is

$$H = \frac{w'\,x}{2\,d} - \frac{w'\,x^2}{2\,d\,l},$$

or greater than the value of H in eq. (24).

Therefore the horizontal strain is greatest under a full load.

Eq. (21),

$$V = \frac{w'\,(l-u)^2}{2\,l^2},$$

is the equation of a parabola, whose vertex is at the abutment and whose diameter is vertical.

Case 5.—A girder supported at both ends and bearing two loads, one a constant load extending over its whole length; the other a partial load extending from one abutment to a point distant u from the other abutment.

Let w = the weight of the constant load.

w' = the weight of a full load whose weight per foot in length is equal to that of the partial load.

u = the distance between the end of the partial load and the abutment.

V = the vertical strain at any point from w.

V' = the vertical strain at the end of the partial load.

l and d = the length and depth of the girder. We use V' because it is the greatest vertical strain a partial load can cause.

From eqs. (14) and (21)

$$V = \frac{w}{2} - \frac{w\,u}{l}, \text{ and } V' = \frac{w'}{2\,l^2}\,(l-u)^2,$$

Adding

$$V + V' = \frac{w}{2} - \frac{w\,u}{l} + \frac{w'\,(l-u)^2}{2\,l^2} \qquad (25)$$

And we obtain an equation of the utmost value, which determines the amount of vertical force at any point in a bridge, resulting from the weight of the bridge itself and the weight of the passing load.

Considering u as measured from the right abutment, it is evident from eq. (25) that at the centre, $V+V' = \frac{w'\,(l-u)^2}{2\,l^2}$, for the vertical strain from the bridge itself at that point is 0, and the centre has therefore the same amount of the partial load to carry as is borne by the right abutment. As we move the load to the right of the centre, the vertical force from the bridge increases with the distance and the vertical force from the load increases as the ordinates of a parabola. But to the left of the centre there is a different effect produced; $-\frac{w\,u}{l}$ then becomes greater than $\frac{w}{2}$ showing a weight going to the left abutment, while $\frac{w'}{2\,l^2}\,(l-u)^2$ has the $+$ sign and passes to the right abutment.

One of these forces neutralizes its amount in the other, as tension and compression cannot exist at the same

time in the same member. And if the value of

$$\frac{w}{2}-\frac{w\,u}{l}+\frac{w'\,(l-u)^2}{2\,l^2},$$

has the + sign the vertical force at that point is borne by the right abutment; if the − sign, it is borne by the left abutment.

If, however, its value is zero, there is no vertical force at that point as there is none in $\frac{w}{2}-\frac{w\,u}{l}$ at the centre.

Consequently beginning at the left end of the bridge, we can move our load on until eq. (25) = 0; as this occurs before we reach the centre, we are then at a point where we must first counterbrace, or brace to carry the weight towards the centre instead of towards the abutment, for then the equation begins to have the + sign.

As this point is of very great importance we will determine it from eq. (25); as u is measured from the right abutment and the load enters at the left end of the bridge, $l-u$ will be the distance from the left end to the point of counterbracing.

Put eq. (25)

$$\frac{w}{2}-\frac{w\,u}{l}+\frac{w'\,(l-u)^2}{2\,l^2}=0.$$

Let $w'=a\,w$, eliminate w and we have

$$\frac{1}{2}-\frac{u}{l}+\frac{a\,l^2-2\,a\,l\,u+a\,u^2}{2\,l^2}=0$$

Multiply by $2\,l^2$, divide by a and transpose, whence

$$u^2-2u\left(l+\frac{l}{a}\right)=-l^2-\frac{l^2}{a},$$

And

$$u^2-2u\left(l+\frac{l}{a}\right)+\left(l+\frac{l}{a}\right)^2=\left(l+\frac{l}{a}\right)^2-l^2-\frac{l^2}{a}$$

Whence

$$u-l=\frac{l}{a}-l\sqrt{\frac{1}{a}+\frac{1}{a^2}} \qquad (26)$$

Ex.—In a bridge whose weight is 150,000 lbs. and whose length is 200 ft., and whose full load is 300,000 lbs., at what distance from the end will counterbracing become necessary under a passing load of equal density with the full load.

Here $w=150{,}000$
$w'=300{,}000$
$a=\frac{w'}{w}=2.$

Answer from eq. (26)

$$l=200.$$
$$\frac{l}{a}-l\sqrt{\frac{1}{a}+\frac{1}{a^2}}=\frac{200}{2}-200\sqrt{\frac{1}{2}+\frac{1}{4}}$$
$$=100-110\sqrt{3}=73.2\text{ ft.}$$

from the abutment.

DIAGRAM OF VERTICAL STRAINS (SEE FIG. 7).

Let A B = the length of the girder,

A G and B F, each $=\frac{w}{2}$, half the weight of the bridge.

A E and B D, each $=\frac{w'}{2}$ half the weight of the full load.

The vertical lines between A B and F G represent the vertical strains from the weight of the bridge.

The vertical lines between A B and D E represent the vertical strains from the weight of a full load.

Therefore the vertical lines between F G and D E represent the vertical strains from the weight of the bridge and the full load.

The weight of the bridge is a constant, but the load is not.

Let the bridge be loaded from B to L then L E‴ represents the portion of the load borne by the right abutment and B D‴ the portion borne by the left abutment, and the vertical lines between G F, D‴ E‴ H represent the vertical strains resulting from the weight of the bridge and the partial load from B to L. Instead of the point of no vertical strain being at c, the centre, it is now moved to the left to where the line E‴ H crosses the line G F. Counter braces would be needed from V to the centre.

Moving the load forward to L′ the vertical lines between D″ E″ and F E″ and between E″ G and E″ H, give the vertical strains, and E″ is the point of no vertical strain. It is here where the weight to the right abutment from the partial load equals the vertical strain to the left abutment from the weight of the bridge, and is the nearest point to the left abutment where counterbracing is needed. This is the point found by eq. (26).

B E‴ E″ E′ E is the parabola described by the vertical strains transmitted to the right abutment by the passing load and the equation of which is eq. (21).

An inverted parabola with its apex at A will give the strains for the left segment of the bridge; or the strains between E′

E″ G are to be applied to both ends of the bridge.

The following are assumed to be admitted without further demonstration.

The upper chord in a bridge of a single span is subject to compression only; the lower chord to tension only.

The weights may, without error, be con-

FIG. 7.

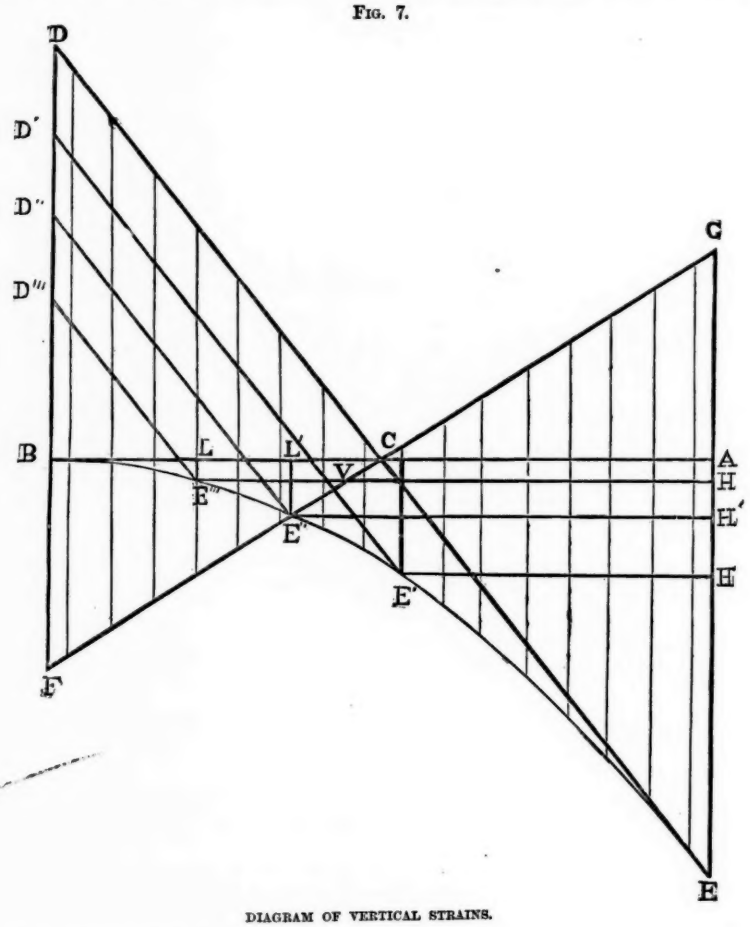


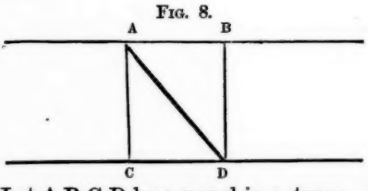
DIAGRAM OF VERTICAL STRAINS.

sidered as concentrated at the ends of the panels, each end supporting the weight resting on the adjacent half panels.

Within a panel there is no change in the strain affecting any one member of the panel, and all strains are longitudinal.

The load being considered as concentrated in weights at the ends of panels, only those inclined and vertical members which are between the weights belong to the same panel.

FIG. 8.



Let A B C D be a panel in a truss. If the weights are at A and B, the members of the panel are A B, C D, A D and D B;

if the weights are at C and D, the members are A B, C D, A C and A D. The panel belongs to that weight which it transfers toward the abutment.

The inclined and vertical members in a panel are subject to the same vertical strain. If the weights are at A and B in Fig. 9, the vertical strain, or the vertical component of the strain in A D is equal to the vertical strain in B D.

The chords receive no vertical strain whatever, and cannot convey a vertical strain from one point to another.

When the upper end of an inclined brace is nearer the centre of a fully loaded bridge or the point of no vertical strain in a partially loaded bridge, than the lower end, it suffers compression and is a strut; when the converse is true it suffers tension and becomes a tie.

The braces between the points of no vertical strain and the centre are counter-braces.

As there are some eccentric cases where the above definitions are not wholly true, a more general one would be: All braces which transmit strains from the upper to the lower chord are struts, those transmitting strains in the opposite direction are ties.

In the following examples application is made of the formulæ and methods given above. The first example is from Col. Merrill"s "Iron Truss Bridges for Railroads," page 68, Plate V., and is termed by him the Jones Truss, more generally known as the Howe truss. The second example is from the same work, page 103, Plate IX., and is termed the Linville Truss, but which originated with Mr. Whipple.

The third is from Mr. Stoney's splendid work on "The Theory of Strains," Vol. I., page 98, and which is called a Warren Girder.

A comparison of the different methods of calculating will show so far as the vertical strains or strains containing vertical components are concerned a very great difference between the results obtained by Col. Merrill and those obtained below, and a small difference in the example taken from Mr. Stoney's work.

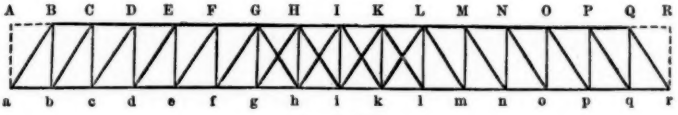
The horizontal strains are identical in the last case and would be in the first two had Col. Merrill made his calculations for a uniform load.

APPLICATION OF THE PRECEDING FORMULÆ.

Example 1*st.*

The inclined braces are struts; the vertical, ties.

FIG. 9.



HOWE TRUSS.

Let $l = 200$ feet, the length of the bridge.
$d = 18.75$ feet, the depth of the truss.
$w = 150{,}000$ lbs., the weight of the bridge.
$w' = 300{,}000$ lbs., the weight of a full uniform load.
$x =$ distance of the end of a panel from one abutment.
$u =$ distance of the centre of a panel from one abutment.
The length of a panel is 12.5 feet.

To ascertain the horizontal strains in this truss which are greatest under a full load, we have eq. (14). (w being equal to $w+w'$).

$$H = \frac{(w + w')\,x}{2\,d} - \frac{(w + w')\,x^2}{2\,d\,l}$$

Whence

$$H = \frac{450{,}000\,x}{2\times 18.75} - \frac{450{,}000\,x^2}{2\times 18.75\times 200} = 12000\,x - 60\,x_2$$

Putting $x = 12.5$, the distance of the ends of the first panels from the abutments,

$$H = 150{,}000 - 9375 = 140{,}625 \text{ lbs.}$$

the amount of horizontal compression at B and Q, and of horizontal tension at b and q. At B and Q the single members which sustain the whole compression are B C and P Q; at b and q the single members which sustain the whole tension are $a\,b$ and $q\,r$. The tension in $b\,c$ and $p\,q$ less the compression in $c\,b$ and P q is equal to that in $a\,b$ and $q\,r$.

In the same manner

When $x = 25$ ft., $H = 300{,}000 - 37{,}500 = 262{,}500$ lbs.

Compression in C D and O P, tension in $b\,c$ and $p\,q$.

When $x = 37.5$ ft., H $= 450{,}000 - 84{,}375 = 365{,}625$ lbs.
Compression in D E and N O, tension in $c\,d$ and $o\,p$.
When $x = 50$ ft., H $= 600{,}000 - 150{,}000 = 450{,}000$ lbs.
Compression in E F and M N, tension in $d\,e$ and $n\,o$.
When $x = 62.5$ ft., H $= 750{,}000 - 234{,}375 = 515{,}625$ lbs.
Compression in F G and L M, tension in $e\,f$ and $m\,n$.
When $x = 75$ ft., H $= 900{,}000 - 337{,}500 = 562{,}500$ lbs.
Compression in G H and K L, tension in $g\,h$ and $l\,m$.
When $x = 87.5$ ft., H $= 1{,}050{,}000 - 459{,}375 = 590{,}625$ lbs.
Compression in H I and I K, tension in $h\,i$ and $k\,l$.
When $x = 100$ ft., H $= 1{,}200{,}000 - 600{,}000 = 600{,}000$ lbs.
Tension in $h\,i$ and $i\,k$.

The above are the greatest strains that can affect any section of either chord. It will be seen from the above that the strains are the same in the two chords on the same side of any one brace.

To obtain the greatest vertical strains or the greatest strains having vertical components, we use eq. (25) giving the effect of the weight of the bridge and the passing load.

$$V = \frac{w}{2} - \frac{w\,u}{l} + \frac{w'\,(l-u)^2}{2\,l^2},$$

Substituting the values of the constants,

$$V = 75000 - 750\,u + 3.75\,(l-u)^2.$$

Making $u = 6.25$, the distance of the centre of the first panel from the abutment.

$$V = 75000 - 4687.5 + 140{,}771.5 = 211{,}084 \text{ lbs.}$$

for the vertical strain in a B and Q r, whose longitudinal strain of compression will be the vertical strain multiplied by the secant of the angle between the brace and the vertical ; this secant is 1.20185.

$$211084 \times 1.20185 = 253{,}691 \text{ lbs.} =$$

compression in a B and Q r, and as the weight is on the lower chord, the ties B b and Q q belong to the first panels, and receive consequently the vertical strain of those panels, and are subject to a tension of 211,084 lbs.

When $u = 18.75$, $l - u = 181.25$,
$V = 75{,}000 - 14{,}062.5 + 123{,}193.4 = 184{,}131$ lbs.
Tension in C c and P p.
$184\,131 \times 1.20185 = 221297.8$ lbs.
Compression in C b and P q.

When $u = 31.25$, $l - u$ 168.75,
$V = 75{,}000 - 23437.5 + 106787.1 = 158{,}350$ lbs.
Tension in D d and O o.
$158{,}350 \times 1.20185 = 190{,}312.9$ lbs.
Compression in D c and O p.

When $u = 43.75$, $l - u = 156.25$.
$V = 75{,}000 - 32812.5 + 91{,}552.7 = 133{,}740$ lbs.
Tension in E e and N n.
$133{,}740 \times 1.20185 = 150{,}735$ lbs.
Compression in E d and N o.

When $u = 56.25$, $l - u = 143.75$,
$V = 75{,}000 - 42{,}187.5 + 77{,}490.2 = 110{,}303$ lbs.
Tension in F f and M m.
$110{,}303 \times 1.20185 = 132567$ lbs.
Compression in F e and M n.

When $u = 68.75$, $l - u = 131.75$,
$V = 75{,}000 - 51{,}562.5 + 64{,}599.6 = 88{,}037$ lbs.
Tension in G g and L l.
$88{,}037 \times 1.20185 = 105{,}807$ lbs.
Compression in G f and L m.

When $u = 81.25$, $l - u = 118.75$,
$V = 75{,}000 - 60{,}937.5 + 52{,}880.8 = 66{,}943$ lbs.
Tension in H h and K k.
$66{,}943 \times 1.20185 = 80{,}455$ lbs.
Compression in H g and $K\,l$.

When $u = 93.75$, $l - u = 106.25$,
$V = 75{,}000 - 70{,}312.5 + 42{,}333.9 = 47{,}022$ lbs.
Tension in I i.
$47{,}022 \times 1.20185 = 56{,}513$ lbs.
Compression in I h and I k.

We have now obtained the greatest tensions in all the ties, and the compressions in the main struts.

When $u = 106.25$, $l - u = 93.75$.
$V = 75{,}000 - 79{,}687.5 + 32{,}958.9 = 28{,}272$,
and $28.272 \times 1.20185 = 33{,}979$ lbs.
Compression in H i and K i.

When $u = 118.75$, $l - u = 81.25$,
$V = 75{,}000 - 89{,}062.5 + 24{,}755.9 = 10{,}694$,
and $10{,}694 \times 1.20185 = 12.853$ lbs.
Compression in G h and L k.

When $u = 131.75$, $l - u = 81.25$.
$V = 75{,}000 - 98{,}437.5 + 17{,}724.6 = -5{,}713$ lbs.

A strain that does not pass to the abutment from which u is measured, as indicated by the sign of the result, and as u is greater than half the length of the bridge, no counterbrace is now needed to carry any strain towards the centre.

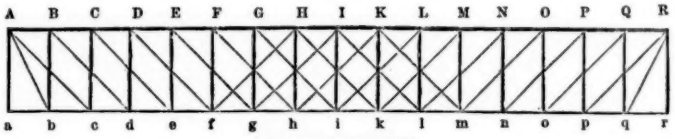
Referring to eq. (26) and the example given, we find that counterbracing becomes necessary at the distance of 73.2 feet from the abutment, which comes within the weight borne by the points g and l.

G h, H i, K i and L k, are all the counterbraces needed in this case.

Example 2*d*.

This truss is merely a combination of two simple trusses, each bearing half the weight, one of which is represented in Fig. 11, and is divided into panels of uniform length.]

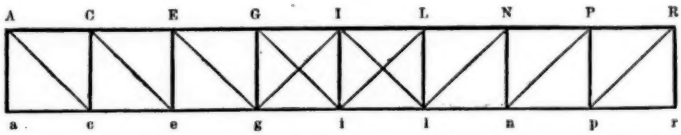
FIG. 10.



THE WHIPPLE TRUSS.

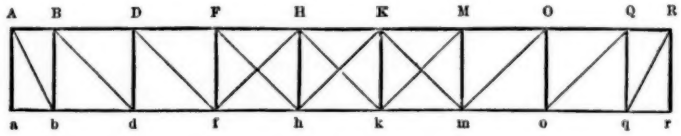
The other represented in Fig. 12 has all the panels of the same length as in Fig. 11, except the end panels, which are of half the length.

FIG. 11.



In this combination of two trusses, the horizontal strains of the two are united in the chords, but the members subject to vertical strains, or strains having vertical

FIG. 12.



components of one truss, act independently of the corresponding members of the other truss.

Let l = 200 ft., the length of the bridge.
d = 25 ft., the depth of the truss.
w = 150,000 lbs. the weight of the bridge.
w' = 300,000 lbs., the weight of a full uniform load.
x = Distance of the end of a panel from one abutment.
u = Distance of the centre of a panel of the simple truss from one abutment.
p = 12.5 ft., the length of a panel.

The simple truss of Fig. 11 can be determined by the application of the eqs. (11) and (15) with w equal to half of the weight of the bridge, and w' half the weight of the full load. But the other truss, Fig. 12, has the half panel at the ends, and prevents the application of eq. (11) in the general form of $H = \frac{w x}{2d} - \frac{w x^2}{2 d l}$, for the reason that while $\frac{w x}{2}$ is the moment of the abutment, $\frac{w x}{4}$ is not the weight on x and $\frac{x}{2}$ is not the distance of its centre of gravity. $\frac{w}{l}(x - p)$ (p being the length of the end panel) is the weight on x, and $\frac{x}{2} + \frac{p}{2}$ is the distance of its centre of gravity. Eq. (11) will therefore assume the form

$$H = \frac{w x}{2d} - \frac{w}{dl}(x-p)\left(\frac{x}{2} + \frac{p}{2}\right) \qquad (27)$$

for the horizontal strains in simple truss (Fig. 12).

If x of eq. (27) be equal to M R in Fig. (12), H will be the horizontal strain in M O, D F, kf and fp.

If x in eq. (11) be equal to L R in Fig. (11), H will be the horizontal strain in L N, E G, il and gi. These two strains added will give M N, E F, kl and gh in Fig. 10.

Hence, the horizontal strain in the upper chord of Fig. (10) at any point is equal to the horizontal strain in that one

of the simple trusses whose panel end is at the same point, added to the strain in that panel end of the other simple truss that comes next towards the centre; or H at x in Fig. 10 is equal to H at x in one of the simple trusses added to H at $x+p$ in the other simple truss. And in the lower chord, H at x in Fig. 10 is equal to H at x in one of the simple trusses added to H at $x-p$ in the simple truss.

In equation (27) making $w = \frac{w+w'}{2}$ we get

$$H = \frac{(w+w')x'}{4d} - \frac{(w+w')}{2dl}(x' - p\left(\frac{x'}{2}+\frac{p}{2}\right)$$

Make $x' = x + p$, and

$$H = \frac{(w+w')x}{4d} + \frac{p(w+w')}{16d} - \frac{(w+w')x^2}{4dl} - \frac{p(w+w')x}{2dl}$$

Adding this to

$$H = \frac{(w+w')x}{4d} - \frac{(w+w)x^2}{4dl}.$$

We obtain

$$H = \frac{(w+w')x}{2d} - \frac{(w+w')x^2}{2dl} - \frac{p(w+w')x}{2dl} + \frac{p(w+w')}{4d} \quad (28)$$

for the horizontal strain at any point in the upper chord of Fig. 10, and in the same manner with $x' = x - p$, we get

$$H = \frac{(w+w')x}{2d} - \frac{(w+w')x^2}{2dl} + \frac{p(w+w')x}{2dl} - \frac{p(w+w')}{4d} \quad (29)$$

for the horizontal strain in the lower chord at any point x.

Substituting the constants eq. (28) we obtain

$$H = 8437.5\,x - 45\,x^2 + 56{,}250.$$

When $x = 12.5$

H = 105,468.75 − 7,031.25 + 56,250 = 154,-687.5 lbs.

Compression in Q R and A B, and tension in *c d and o p*.

When $x = 25$.

H = 210,937.5 − 28,125 + 56,250 = 239,-062.5 lbs,

Compression in R Q and B C, and tension in *d e* and *n o*.

When $x = 37.5$.

H = 316,406.25 − 63,281.25 + 56,250 = 309,375 lbs.

Compression in O P and C D, and tension in *e f* and *m n*.

When $x = 50$.

H = 421,875 − 112,500 + 56,250 = 365,625 lbs.

Compression in N O and D E, and tension in *f g* and *l m*.

When $x = 62.5$.

H = 527,343 75 − 175,781.25 + 56,250 = 407,812.5 lbs.

Compression in M N and E F, and tension in *g h* and *k l*.

When $x = 75$.

H = 632,812.5 − 253,125 + 56250 = 435,-937.5 lbs.

Compression in L M and F G, and tension in *h i* and *i k*.

When $x = 87.5$.

H = 738,281.25 − 344,531.25 + 56,250 = 450,000 lbs.

Compression in G H and K L.

When $x = 100$.

H = 843,750 − 450,000 + 56,250 = 450,000 lbs.

Compression in H I and I K.

The tension in *b c* and *p q* can he found from eq. (29), where

$$H = 9562.5 - 45\,x^2 - 56{,}250.$$

When $x = 12.5$.

H = 119531.25 − 7031.25 − 56,250 = 56,250 lbs.

When $x = 25$.

H = 239062.5 − 28125 − 56,250 = 154,687.5 lbs.

Tension in *c d and o p*,

same as found in the upper chord on the same side of same inclined brace.

As there is no connection between the members of the two simple trusses subject to vertical strains, in the compound truss, equation (25) will retain the same form. w and w' necessarily becoming $\frac{w}{2}$ and $\frac{w'}{2}$, each simple truss bearing half the weight of the full load and of the bridge. u being the distance to the centre of a panel of the simple trusses, becomes the distance to the end of a panel of a compound truss, and since the truss in Fig. 12 has the centre of the end panel at the end of the truss, the first value of V is when $u = 0$.

Substituting the values of the constants,

$$V = \frac{w}{4} - \frac{wx}{2l} + \frac{w'(l-u)^2}{4l^2} = 37500 - 375\,u + 1.875\,(l-u)^2,$$

When $u = 0$.

V = 37500 + 75000 = 112,500 lbs.

Compression in end posts A *a* and R *r*.

and 112,500 × 1.20185 the secant of the angle Q *q* R = 135208 lbs. tension in ties *q* R and A *b*.

When $u = 12.5$.

V = 37500 − 4687.5 + 32812.5 = 98731 lbs.

Compression in end posts A *a* and R *r*, which added to the amount obtained previously makes the total amount of compression in these posts to be 211,231 lbs.

98731 × 1.414 secant of angle R *p r* = 139626 lbs. Tension in *p R* and *A c*.

When $u = 25$.
$V = 37500 - 9375 + 57422 = 85{,}547$.
Compression in Q q and B b.
$85.547 \times 1.414 = 120{,}963$ lbs.
Tension in o Q and B d.

When $u = 37.5$.
$V = 37500 - 14062 + 49512 = 72{,}949$ lbs.
Compression in P p and C c.
$72.949 \times 1.414 = 103{,}150$ lbs.
Tension in n P and C e.

When $u = 50$.
$V = 37500 - 18750 + 42188 = 60938$ lbs.
Compression in O o and D d.
$60938 \times 1.414 = 86{,}166$ lbs.
Tension in m O and D f.

When $u = 62.5$.
$V = 37500 - 23438 + 35449 = 49512$ lbs.
Compression in N n and E e.
$49512 \times 1.414 = 70010$ lbs.
Tension in l N and E g.

When $u = 75$.
$V = 37{,}500 = 28125 + 29297 = 38672$ lbs.
Compression in M m and F f.
$38672 \times 1.414 = 54{,}682$ lbs.
Tension in k M and F h.

When $u = 87.5$.
$V = 37500 - 32812 + 23730 = 28418$ lbs.
Compression in L l and G g.
$28418 \times 1.414 = 40183$ lbs.
Tension in i L and G i.

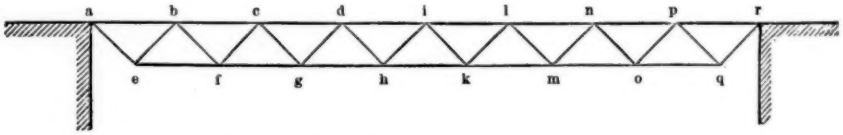
When $u = 100$.
$V = 37500 - 37500 + 18750 = 18750$ lbs.
Compression in K k and H h.
$18750 \times 1.414 = 26413$ lbs.
Tension in h K and H k counterbraces.

When $u = 112.5$.
$V = 37500 - 42187 + 14355 = 9668$ lbs.
Compression in l i.
$9668 \times 1.414 = 13670$ lbs.
Tension in g I and I l, counterbraces.

When $u = 125$.
$V = 37500 - 46875 + 10547 = 1172$ and
$1172 \times 1.414 = 1657$ lbs.
Tension in f H and K m, counterbraces.

When $u = 137.5$ r has the minus sign, or the weight no longer passes to the abutment from which u is measured, and consequently no more counterbraces are necessary.

FIG. 13.



Let Fig. 13 represent a Warren Girder the bracing of which is formed of eight right angled isosceles triangles, with the roadway attached to the upper flange or chord. Let the permanent bridge load equal half a ton per running foot and the greatest passing train of uniform density equal to one ton per foot.

$w = 40$ tons.
$w' = 80$ tons.
$l = 80$ feet.
$d = 5$ feet.

The length of a panel is the distance on the upper chord between the apices of the triangles, which is 10 feet.

x = The distance of the apex of any triangle from the abutment.
u = The distance of the centre of a panel from one abutment.

Applying the horizontal equation (11)

$$H = \frac{w x}{2 d} - \frac{w x^2}{2 d l}$$

with x equal to the length of one panel, we get the horizontal strain at b in the upper chord, and the horizontal strain in $e f$ of the lower chord; but the strain at b is partly in $b c$ and partly in $b f$ and we have no single member at that point to sustain the whole horizontal strain. The equation, however, can be adapted to points at the centres of the panels.

Let x' = distance of the centre of any panel from the abutment.
h = half the length of a panel.

$\frac{w x'}{2}$ will be the moment of the reaction of the abutment, and $\frac{w}{l} \times h \times x'$ will be the moment of the half panel load resting immediately on the abutment.

$\frac{w}{l}(x' - h)$ is the balance of the load upon x' and.

$\frac{x' - h}{2}$ is the distance of its centre of gravity.

Whence

$$H = \frac{w x'}{2 d} - \left\{ \frac{w x'^2}{2 d l} + \frac{w h^2}{2 d l} \right\}, \qquad (30)$$

An equation giving the strains in the upper chord of a Warren Girder, where x' is the distance of the apices of the inverted triangles on the lower chord, and h half the length of a panel, and w the weight of the full load and the bridge.

Substituting the values of the constants, we get

$$H = 12 x' - \frac{3 x'^2}{20} - 3.75.$$

With $x' = 5$.
$H = 60 - 3.75 - 3.75 = 52.5$ tons.
Compression in $a b$ and $p r$.

When $x' = 15$.
$H = 180 - 33.75 - 3.75 = 142.5$ tons.
Compression in $b\,c$ and $n\,p$.

When $x' = 25$.
$H = 300 - 93.75 - 3.75 = 202.5$ tons.
Compression in $c\,d$ and $l\,n$.

When $x' = 35$.
$H = 420 - 183.75 - 3.75 = 232.5$ tons.
Compression in $d\,i$ and $i\,l$.

For the lower chord substitute the constants in

$$H = \frac{(w + w')\,x}{2\,d} - \frac{(w + w')x^2}{2\,d\,l},$$

Whence $$H = 12\,x - \frac{3\,x^2}{20}$$

When $x = 10$.
$H = 150 - 15 = 105$ tons.
Tension in $e\,f$ and $o\,q$.

When $x = 20$.
$H = 240 - 60 = 180$ tons.
Tension in $f\,g$ and $m\,o$.

When $x = 30$.
$H = 360 - 135 = 225$ tons,
Tension in $g\,h$ and $k\,m$.

When $x = 40$.
$H = 480 - 240 = 240$ tons.
Tension in $h\,k$.

Substituting the values of the constants in

$$V = \frac{w}{2} - \frac{w\,u}{l} + \frac{w'\,(l-u)^2}{2\,l^2},$$

We get

$$V = 20 - \frac{u}{2} + \frac{(l-u)^2}{160},$$

When $u = 5$.
$V = 20 - 2.5 + 35.15 = 52.65$ multiplied by 1.414 secant of the angle of inclination of the brace $= 74.4$ tons.
Compression in $p\,q$ and $b\,e$, and tension in $a\,e$ and $q\,r$.

When $u = 15$.
$V = 20 - 7.5 + 25.75 = 38.28$, and $\times$ 1.414 $= 54.1$ tons.
Compression in $n\,o$ and $c\,f$, and tension in $b\,f$ and $o\,p$.

When $u = 25$.
$V = 20 - 12.5 + 18.9 = 26.4$ and $\times$ 1.414 $=$ 37.3 tons.
Compression in $l\,m$ and $d\,g$, and tension in $m\,n$ and $c\,g$.

When $u = 35$.
$V = 20 - 19.5 + 12.65 = 15.15$, and $\times$ 1.414 $= 21.4$ tons.
Compression in $i\,k$ and $i\,h$, and tension in $k\,l$ and $d\,h$.

When $u = 45$.
$V = 20 - 22.5 + 7.66 = 5.16$ and $\times$ 1.414 $=$ 7.3 tons.
Compression in $d\,h$ and $k\,l$, and tension in $h\,i$ and $i\,k$.

When $u = 55$, V has the minus sign, and there is no further need of counterbracing.

It will be observed that $d\,h$, $h\,i$, $i\,k$ and $k\,l$ are subject to both tension and compression under a moving load, and are consequently counterbraces. The other braces are subject to either tension or compression only and are main braces.

Comparing this with the formula for the commencement of counterbracing, eq. (26.)

$$\frac{l}{a} - l\sqrt{\frac{1}{a} + \frac{1}{a^2}}$$
$$l = 80 \qquad a = 2$$

We obtain 29.2 ft., or counterbracing becomes necessary at 29.2 ft. from the abutment, which is within the weight borne by the third apex.

There is a slight difference between these results, and those obtained by Mr. Stoney, amounting in the strains to which the braces are subject to about $\frac{1}{10}$ of a ton; but the results as regards the horizontal strains and the counterbracing are identical.

The difference in the strains affecting the braces can be easily explained. Though Mr. Stoney considers the passing load equal to 1 ton per running foot, he makes 35 tons instead of 40 tons, a load covering half the girder. His partial load never extends from the abutment to the centre of a panel, but from a point half way between the abutment and the first apex. He begins by estimating the strains resulting from a weight on b, of 10 tons, then adds the weight on c, etc. But this is an almost impossible case. If b be fully loaded, and the end of the train half way between b and c, the girder will certainly be loaded to a, and the right abutment will have its proportion of 15 tons, instead of 10 tons, to bear. The difference, however, is small, and is a constant, as can be seen from the equation.

M. Cotelle, says the "Pharmacist," has invented a cheap substitute for the platinum still used in distillation of sulphuric acid. It consists of a stone tower, into which the acid drops in small quantities, while a current of hot air enters at the bottom and drives over the acid, which is condensed in the usual way.

According to "Cosmos," the vapor which is frequently disengaged on the first application of heat to the oxide of copper in the combustion tube, used in organic analysis, arises from the presence of a small quantity of selenium. M. Violette is credited with the discovery.

TWO-STORIED RAILWAY CARRIAGES.

From "Engineering."

For more than 20 years past there have been extensively used on some of the French railways carriages with seats on the roof, or "voitures à impériale," as they are usually called. According to a recent return the Western Railway of France possessed 526, the Eastern Railway, 236, and the Northern, 150 of these carriages, and the results obtained by their employment appear to be in every way satisfactory, it being found that they ride easily, and that they are no more liable to derailment than ordinary single-storied vehicles. The "voitures à impériale" are principally employed for the local traffic in the neighborhood of Paris, and in summer time, when the heat is great, it is no uncommon thing for the roof seats to be completely filled, whilst those in the lower body are almost empty; yet, notwithstanding this apparently somewhat risky method of loading, and the liability to derailment which it might be supposed to induce while the trains were traversing curves, we believe that no accident has ever occurred which could be fairly attributed to this cause. In some degree this result is no doubt due to the fact that in the ordinary "voitures à impériale," the upper seats and the roof or awning which covers them are made as light as possible, while at the sides the upper body is left open, no protection whatever from the weather being provided. At some seasons of the year this is a considerable defect, and it was with a view of remedying it, and at the same time retaining the advantages of the "voitures à impériale," that M. J. B. Vidard, a few years ago, introduced the regular two-storied carriages, such as are now in use on the Eastern Railway.

In these carriages, of which we published engravings and a description about 3 years ago (*vide* page 207 of our third volume), the upper seats are contained in a regular "body" provided with side windows and end doors, while to prevent the centre of gravity from being raised too high, the frame is lowered so that the lower body is at a much less height above the rails than usual. By this means, and by keeping the heights of the compartment rather small—the lower body being but 5 ft. 5 in. high at the centre—the total height of the carriages is kept down to less than 13 ft. 8 in., while the centre of gravity is not greatly higher than that of ordinary vehicles, as the following Table lately prepared by M. Vidard, will show.

Class of Vehicles.	Weight of each Part of the Carriage.	Height of the Centre of Gravity of each Part of the Carriage.		Weight of each Part added successfully to that of the Parts Preceding.	Height above Rail of the Centre of Gravity of the Weight given in the preceding Column.
		Above the Centre of Gravity of the preceding Part.	Above the Rail Level.		
Ordinary 2d Class Carriage:	cwt.	ft. in.	ft. in.	cwt.	ft. in.
Two pairs of wheels, axles, etc.	34	1 7½	1 7½	34	1 7½
Frame	38	1 7½	3 3	72	2 6½
Body	54	2 11½	6 2½	126	4 1½
"Voiture à Impériale:"					
Two pairs of wheels, axles, etc.	32	1 7½	1 7½	32	1 7½
Frame	48	1 7½	3 3	80	2 7½
Lower body	60	2 10½	6 1½	140	4 1½
Impériale	18	4 9½	10 10⅝	158	4 11
Two-Storied Carriage:					
Two pairs of wheels, axles, etc.	30	1 5¾	1 5¾	30	1 5¾
Frame	40	0 11½	2 5⅝	70	2 0½
Lower body	60	4 11	7 4⅝	130	3 4½
Upper body	26	3 1¾	10 6¾	156	4 6½

It will be seen from this Table, that the heights above rail level, of the centres of gravity of the ordinary carriages, the "voitures à impériale," and M. Vidard's two-storied carriage, are respectively 4 ft. $1\frac{1}{4}$ in., 4 ft. 11 in., and 4 ft. $6\frac{1}{8}$ in., these heights referring to the position of the centres of gravity with the carriages empty. When the vehicles are loaded, the low position of the seats in the Vidard carriages causes their centre of gravity under those circumstances to be still further below that of the "voitures à impériale."

The Table also shows that if the Vidard carriage had the upper story removed, its centre of gravity would then be but 3 ft. $4\frac{3}{8}$ in. above the rail level, or $9\frac{7}{8}$ in. below that of a carriage of ordinary construction, and this is a point which under some circumstances might render it advisable to adopt the lowered frame used by M. Vidard even when the upper story was not required. In the case of cheaply constructed branch lines, moreover, where it is desired to avoid the erection of platforms, the lowered frame enables ready access to be had to the compartments with but a single step. On such lines as those we have just mentioned, we believe that two-storied carriages constructed on M. Vidard's plans could be very advantageously employed, as their dead weight is really very small in proportion to the load carried. Thus the Vidard carriages on the Eastern Railway of France carry from 68 to 80 persons according to the class, those carriages accommodating 80 passengers being entirely third class. In all cases 40 third class passengers are accommodated in the upper body, and it will be seen, on reference to the Table, that this accommodation is obtained with an increase of weight of but 30 cwt., as compared with that of an ordinary second class carriage. The total weight of one of these two-storied carriages fully loaded is about 13 tons, or about $3\frac{1}{4}$ tons per wheel, and this is a load which is by no means excessive, even for a "light" railway. In this country, where we have of late years become accustomed to lofty and roomy carriages, we do not believe that the somewhat cramped proportions of the Vidard carriages would be tolerated on our principal lines, even for short distance traffic. In the case of country branch lines, however, or in the case of the economically constructed light railways, which are likely, before many years are over, to spring up in numerous districts, the case is different, and we believe that those interested in the construction and working of such lines might turn their attention to two-storied carriages with advantage.

A Puzzling Possibility. — When the Russian-American Telegraph is completed, the following feat will be possible: A telegram from Alaska for New York, leaving Sitka, say at 6.40 Monday morning, would be received at Nickolaef, Siberia, at 6 minutes past 1 on Tuesday morning; at St. Petersburg, Russia, at 3 minutes past 6 Monday evening; at London at 22 minutes past 4 Monday afternoon; and at New York at 46 minutes past 11 Monday forenoon. Thus, allowing 20 minutes for each re-transmission, a message may start on the morning of one day, to be received and transmitted the next day, again received and sent on the afternoon of the day it starts, and finally reach its destination on the forenoon of the first day. The whole taking place in one hour's time.

Railways are all the vogue in Chili and Peru. The Concepcion and Chilian line progresses rapidly. A road is projected across the Andes. On the 1st of February last a railway from Callao to Oroya was commenced, the latter point being connected by navigable rivers with the Atlantic Ocean. Another new line is being made in Peru to run from Arequipa to Puno, and thus connect the Pacific with Lake Titicaca. The Oroya line will be 222 miles long, with 27 tunnels and 17 bridges; the cost is put down at $27\frac{1}{2}$ million dollars, the Government giving 6 per cent. interest and 2 per cent. amortisation. The Arequipa line will be 137 miles long, with 12 great tunnels, and costing 32 million dollars.

Pennsylvania has produced 28,000,000 barrels of petroleum in 10 years; and a larger quantity has been brought from the bowels of the earth, during the last year, than was brought forward in the height of the "oil fever."

DOUBLE STEAM BOILERS.

From "Engineering."

M. C. Felix, of Paris, has recently communicated to the "Bulletin Mensuel de la Société des Anciens Elevés des Ecoles Imperiales d'Arts et Metiers," a proposal for a system of double steam boilers, which, though not absolutely novel, nor yet perhaps capable of very general application, is yet well worthy of some notice in our pages. The system advocated by M. Felix is a very simple one, and consists merely in adding to an ordinary boiler a second boiler so arranged that it is heated by the steam in the first. Thus, in one case, it is proposed to provide the first boiler with a dome of unusual size, this dome being divided horizontally by a plate, from which tubes depend into the steam space of the boiler. The upper part of the dome above the division plate forms, in this case, the boiler from which the steam is drawn for the supply of the engine.

The first boiler is heated by a fire in the usual way, but inasmuch as all the steam formed in it is condensed by contact with the tubes of the second boiler, the contained water is evaporated over and over again, and the only fresh supply needed is that required to make up losses by leakage. It is claimed as one of the advantages of the system, that inasmuch as there is no renewal of the water in the first boiler (except the slow renewal rendered necessary by leakage) there can be no formation of incrustation on the surfaces exposed to the fire; while, on the other hand, in the second boiler—where of course incrustation will form as usual—none of the surfaces incrusted are exposed to a higher temperature than that of the steam in the first boiler. These are, of course, undoubted advantages, but whether they are of such great value as to outweigh the extra cost of a boiler constructed on the "double" system is another matter; in some instances we believe they may have this value, but certainly not in the majority of cases.

It is, of course, necessary in order that the heat may be freely communicated from the first to the second boiler, that the former should be worked at a higher pressure than the latter. M. Felix proposes a difference of pressure of two atmospheres, or about 30 lbs. per square inch, and of course the higher the difference of pressure, and the greater therefore the difference between the temperature of the steam in the two boilers, the less will be the area of heat-absorbing surface which it will be necessary that the second boiler should have in order to supply a given quantity of steam. M. Felix assumes as the basis of his calculations concerning the requisite area of what we may term the intermediate heating surface, that one square metre of such surface will evaporate 8 kilogammes of water per hour for each degree (centigrade) of difference of temperature between the steam and water. Reduced to English dimensions, this is equal to an evaporation of about 0.9 lbs. of water per sq. ft. of steam-heated surface per degree (Fahr.) of difference of temperature between the steam and water. No doubt, results as high as this have been obtained in certain cases where there has been a rapid circulation of water over the steam-heated surfaces; but these are exceptionable instances, and in ordinary practice—taking into consideration that the surfaces are liable to become coated with incrustation—it would not be safe to depend upon a rate of heat transmission more than one-third as great as that above mentioned, or say, a transmission equal to the evaporation of 0.3 lb. of water per square foot of surface per hour per degree of difference of temperature.

With steam at a pressure of 90 lbs. per square inch in the first, and 60 lbs. per square inch in the second boiler, there would be an available difference of temperature of about 24 deg., and according to the data just given the evaporation in the second boiler would thus be equal to $24 \times 0.3 = 7.2$ lbs. per square foot of "intermediate" heating surface per hour. In other words, about 8.7 square feet of "intermediate" heating surface would be required for each cubic foot of water to be evaporated per hour in the second boiler—an area which would probably render the cost of the double boiler nearly, or quite, equal to that of two boilers of equal power constructed on the ordinary system.

IRON AND STEEL NOTES.

THE IRON TRADE IN FRANCE.—The markets of the Haute Vienne are in good condition, business satisfactory and impressions favorable; quotations all firm, and in some instances on the rise. Charcoal iron very scarce, and not to be had under 125 f. Wrought iron in good demand as regards machine iron and its derivations at the following rates:—Coke iron, rolled, 200 f. to 225 f.; mixed ditto, first quality, 220 f. to 225 f.; charcoal, ditto, first quality, 235 f. to 240 f.; ditto, second quality, 225 f. to 235 f. The works that produce rod and machine iron have orders in hand for several months ahead. Good qualities of mixed iron for drawing, worth 235 f. to 240 f. Machine iron for chain work about the same. Hammered iron stands at 245 f. to 250 f. for bar, and at 250 f. to 255 f. for axles. Iron wire and nails are in demand and on the rise. The drought has caused a falling off in the make, but the late fall of rain will have corrected this. The entries of special cast and wrought iron in Paris for building purposes continue to fall off, as compared with the amounts of former years, as will be seen by the following returns for three years:—Wrought iron, month of March, 1870, 2352 tons; 1869, 3652 tons; 1868, 4305 tons; cast iron, 1870, 759 tons; 1869, 1318 tons; 1868, 1321 tons. Wrought iron, first quarter of the year, 1870, 4999 tons; 1869, 10,101 tons; 1868, 1370 tons; cast iron, 1870, 2396 tons; 1869, 3964 tons; 1868, 3359 tons. The inquiry respecting the textile industries is expected to be completed during the next fortnight, when that relating to the metal trades will be taken in hand.—*The Engineer.*

NOT infrequently does an iron ore from a particular bank or locality acquire from the furnace-master a reputation for cold or red-short tendencies which does not justly belong to it, from the fact of the presence of notable amounts of sulphur and phosphorus in the flux used with it. As the analysis of limestones are most generally conducted, the presence of these elements is either overlooked or their quantities are not estimated. We believe that if this point were properly and fairly appreciated, many variations in a furnace's product would be understood, and a proper corrective applied. Some time since, with this special object in view, we examined into some limestones employed at different furnaces, and in all our samples found both sulphur and phosphorus, the former probably existing as sulphuret of iron or sulphate of lime, and the latter as phosphate of the same base. The following result, centesimally expressed, will illustrate to what amount these substances may exist and yet be overlooked unless special research be made for them:—

Carbonate of lime 86.23, carbonate of magnesia 2.82, phosphate of lime 0.87, sulphate of lime 0.28, alumina and oxide of iron 1.01, matter insoluble in acids 8.25, organic matter 0.28, = 99.74.

The amount of phosphate of lime corresponds to 0.17 per cent. of phosphorus, or 3.4 lbs to every ton; that of the sulphate to 0.06 per cent. of sulphur, or 1.2 lb. to the ton. The specimen was of a brecciated structure, and was from a Pennsylvanian locality. When the circumstances under which limestones are formed are properly considered, it must be evident that these, as well as other foreign matters, must necessarily be present in greater or less amounts. Most of them, when properly examined, will exhibit also noteworthy amounts of the alkalies, probably existing in the condition of chlorides.—*American Exchange and Review.*

THE MANUFACTURE OF ANTHRACITE PIG IRON.—During the year 1869 the production of anthracite pig iron in the United States amounted to 971,150 tons of 2,000 lbs., as follows:

	Tons.
Massachusetts	4,200
New York	210,855
New Jersey	54,201
Pennsylvania	692,739
Maryland	9,155
Total	971,150

The following statement shows the progress of this branch of manufacture since 1860:

Year.	Production, in tons of 2,000 lbs.
1860	519,211
1861	409,229
1862	470,315
1863	577,638
1864	684,018
1865	479,558
1866	749,367
1867	798,638
1868	893,000
1869	971,150

—*Bulletin of Am. Iron and Steel Association.*

THE following are the average prices, during the last ten years, for rails of best quality, in France, all accessory pieces supplied with them:

	Per ton Fr.	cts.	Per ton £.	s.	d.	U. S. Equivalent, gold. $	cts.
1860	159	75	6	7	9	30	91
1861	161	50	6	9	2	31	26
1862	150	45	6	0	0	29	04
1863	149	20	5	19	0	28	80
1864	160	75	6	8	7	31	12
1865	161	80	6	9	5	31	32
1866	160	10	6	8	10	31	18
1867	156	70	6	5	4	30	33
1868	148	80	5	19	6	28	92
1869	158	25	6	6	7	30	60
Present price.	180	00	7	4	0	34	85

—*Bulletin of Am. Iron and Steel Association.*

IRON AND STEEL.—The invention of Mr. J. Player, Philadelphia, U. S. A., consists in first dividing the cast-iron in the condition in which it is left by the smelting operation into small pieces, flakes, grains, or powder, by mechanical means, and then mixing it in a solid state, and in this minutely divided condition, with the oxides or other ingredients or agents designed to improve or purify it, or to aid in its conversion into steel or malleable iron, while such oxides or ingredients, or agents, are also in a solid state, and afterwards subjecting it to the puddling process or other manipulation intended to free it from its excess of carbon and from its impurities, so that in such manipulation the requisite mixture of the iron and purifying agents may be secured in the highest practicable degree. —*Mining Journal.*

THE following is a statement of the export of rails from Great Britain during the month ended April 30, and the four months ended April 30,

1870, and the corrosponding periods of the years 1868 and 1869; also, the quantity of pig iron exported to the United States during the same periods, compiled from official returns published by authority of the House of Commons:

COUNTRIES.	Month ended April 30.		
	1868. Tons.*	1869. Tons.	1870. Tons.
AMERICA.			
United States	35,970	37,592	41,457
British	4,416	5,326	6,015
Cuba	572	....	1,219
Brazil	731	....	319
Chili	11	....	405
Peru	6	1,444	....
EUROPE.			
Russia	2,261	23,705	23,093
Sweden	171	3,225	....
Prussia	2,223	91	5,379
Illyria, Croatia, and Dalmatia	174	2,133	2,672
France	3	1,330	11
Holland	2,538	1,056	3,630
Spain and Canaries	2,209	3,050	1,249
ASIA.			
British India	8,978	7,299	17,894
Australia	789	1,663	1,008
AFRICA.			
Egypt	972	345	210
OTHER COUNTRIES.	3,944	7,109	3,913
Total	65,968	95,378	108,474
Pig Iron to U. S.	9,475	19,149	7,416

COUNTRIES.	Four Months ended April 30.		
	1868. Tons.	1869. Tons.	1870. Tons.
AMERICA.			
United States	98,993	129,996	131,831
British	5,802	9,187	9,748
Cuba	1,222	357	1,807
Brazil	2,017	603	2,164
Chili	304	1,857	6,388
Peru	105	9,430	3,283
EUROPE.			
Russia	2,485	33,145	27,692
Sweden	182	3,225	....
Prussia	2,223	1,389	12,793
Illyria, Croatia, and Dalmatia	4,269	12,432	15,200
France	15	2,559	163
Holland	12,401	3,691	8,103
Spain and Canaries	3,974	4,917	8,207
ASIA.			
British India	39,377	20,613	82,522
Australia	3,837	7,954	4,947
AFRICA			
Egypt	11,772	2,425	1,703
OTHER COUNTRIES.	11,520	17,659	26,091
Total	200,499	261,439	342,642
Pig Iron to U. S.	16,046	48,013	31,681

* Tons in all cases 2,000 lbs.

PATENT FOR A COLD TINNING PROCESS.—M. Daubie, iron-master, Blanc Murger Works, at Bellefontaine, in the Vosges, obtained in November last a patent for tinning by a cold process, in order to prevent oxidation of iron in general, and especially of iron wire, employed in the fabrication of cards and wire cloth, without altering its polish or rigidity. An addition to the patent was made on the 30th December. The inventor's chief object is to prevent the softening of the metal, and the mode adopted is successive immersion in baths containing cold solutions of salts of tin, with the addition of a certain amount of organic matter, such as fecula or starch, which has always been found valuable both in tinning and galvanization. The solution patented is composed as follows:—To every twenty gallons of water add 6 lbs. of rye flour, and let it boil for about half an hour; filter it, and afterwards add 112 lbs. of pyrophosphate of soda, 34 lbs. of crystallized salt of tin, 134 lbs. of neutral protochloride of tin, and from 3 oz. to 4 oz. of sulphuric acid. When the salts are dissolved the solution is distributed in eight or ten wooden vats, a little additional water being added to the first two or three of the vats. The wire is passed successively through the whole of the vats, and if great brilliancy of surface is required, also through draw plates at intervals, and the wire, while retaining all its rigidity, becomes covered with a brilliantly-polished coat of tin. Beautiful and inoxidizable cards and wire cloth have been produced by this process, which is applicable to wire for a hundred different purposes. M. Daubie, we are told, has also succeeded in silvering iron wire, by using, in place of the salts of tin in the solution, cyanide of silver and cyanide of potassium.—*The Engineer.*

IRON AND STEEL.—The invention of Mr. Charles W. Siemens, of Great George street, consists of an improved mode of introducing the reduced ore into the open hearth of the melting furnace without, on the one hand, exposing the reduced ore to the oxidizing action of the flame, and, on the other hand, without exposing the reducing hoppers, retorts, or muffles to the extreme heat of the smelting furnace. For this purpose the inventor does not discharge the reduced ore directly into the melting furnace, as heretofore, but into a chamber or chambers arranged at the back or along the sides of the same, in which chamber or chambers a reducing atmosphere is maintained by an influx of reduction gases, although there exists an open communication between the chamber and the furnace. The bottom surface of the chamber inclines towards the hearth of the melting furnace upon which the metallic bath is prepared, in order to facilitate the introduction of the reduced ore into the bath, when required, by means of rabbles introduced through a door or doors opposite the melting chamber. From this reduced ore chamber or chambers vertical or inclined hoppers or retorts rise upwards, into which the raw or calcined ore, together with the reducing and fluxing materials, are charged from above, by preference in a heated condition, and around these hoppers or retorts channels are provided, through which flame is made to circulate.—*Mining Journal.*

A REMARKABLE instance of the crystallization of metallic iron was noticed recently during an examination by Mr. Crookes of the Heaton or nitrate of soda process for the production of refined

iron. After the subsidence of the violent action which ensues when the nitrate of soda is in contact with the molten metal, the converter, or lower portion of the apparatus, is detached, and after a few minutes, the contents are turned out upon the floor in the form of a porous mass, weighing nearly three-fourths of a ton. A careful inspection of this mass of somewhat refined iron showed it to consist of minute cubical crystals, segregating or arranging themselves in feather-like groups. The crystals are said to be sharp and well-defined, and to present an exceedingly beautiful appearance. Such phenomena are by no means uncommon on the gradual cooling of masses of other metals, but the instances in which they have been noticed with regard to iron are very rare. During a recent visit to the smelting works of a mine in Wythe county, Virginia, we were able to procure exceedingly well-defined and quite large cubes of metallic lead, while the production of crystals of bismuth and some other metals, by a method of slow cooling, is described in most works on chemistry.—*American Exchange and Review.*

Iron and Steel.—By the invention of Messrs. P. R. Hodge, Adam street, Adelphi, C. Hengst, Fulham road, and N. Wilson, Holborn, they prefer to use, and claim as new, a flux composed of calcined borax (say), 1 oz., combined with essential oil of rosemary, or any of the essential oils, mixed with iron filings or iron powder, made very fine and mixed uniformly with the calcined borax and essential oil. This compound is put on the surface of the materials to be combined together, after being heated to about 240 deg. to 260 deg. Fahr., and then heated up in a close muffle or hollow fire, or a close heating furnace to a red heat.

Transformation of Cast Iron.—"Transformation of cast iron, wrought iron, and steel by means of the vapors of alkaline metals." Such is the title of a patent taken in France by MM. Charles Girard and Jules Poulain (date 17th August, 1869. No. 86,784), the particulars of which we extract from our excellent contemporary, the "Moniteur Scientifique":—

"In order to cause the vapors of sodium and potassium to act on cast iron in fusion, we heat one of the former metals in an iron retort to 392 deg. or 482 deg. under a pressure of five or six atmospheres. When this heat is reached we direct the vapor thus obtained into the heart of the iron in fusion; the mass swells, and an alloy of the iron is the result. These alloys, although very hard, are malleable, and may be forged and welded. They oxidize rapidly in air or water, and are easily decomposed if a current of air, steam, or carbonic oxide, is injected into them when in fusion. By these compound effects of the vapor of sodium and of air, for example, the whole of the metalloids in the iron are attacked, and the final result is pure wrought iron that can be hammered and welded with ease. Under certain circumstances the metal resulting from the operation may present the properties of steel. Finally, to facilitate the production of the metallic vapors, carburets rich in hydrogen may be added to the sodium or potassium in the retort.

"In place of sodium or potassium an alloy of the two may be used, as, for instance, one composed of 4 parts of potassium (melting at 122 deg.) and 2.5 parts of sodium (melting at 194 deg.). This mixture, which has the appearance and consistency of mercury, has its point of solidification at 47.4 deg., and is consequently liquid at ordinary temperatures. It is prepared under naphtha.

"It has been remarked that, besides the direct transformation of cast into wrought iron or steel, by means of the metals, their action produces other advantages; they allow of the employment of cast iron, which, although containing manganese, are reputed as bad, and cannot be converted by the Bessemer process, on account of the quantity of carbon, sulphur, or phosphorus which they contain. It is, in fact, now proved that the Bessemer process, far from eliminating the sulphur and phosphorus, tends rather to augment the proportion of these metalloids.

"The cast irons known as *chaudes*, and which contain silicium and magnesium, owe a part of their superiority to the calorific power of the silicium (7,800), the produce of the oxidation of which, silica, requires but little heat to disengage it, so that the liquefaction becomes more complete. On the other hand, carbon, under the same conditions, gives rise to the disengagement of masses of sparks produced by the gases, carbonic acid and carbonic oxide, which traverse the mass; these take from the molten matter a considerable quantity of caloric, and thus are unfavorable to liquefaction.

"In our process this latter inconvenience is partly dispelled, for the gases produced by the combustion of the carbon, sulphur, and phosphorus, combine with the soda or potash, and are mechanically carried through the mass of metal by the oxidation of the sodium or potassium.

"The direct action of the sodium or potassium, in the form of vapor, on the melted iron may be replaced by adding to the mixture of ore, fuel, and flux, either chloride of sodium, carbonate of soda, a corresponding salt of potash, or a mixture of these. Acting thus on any given ore, and using coke or coal as fuel, a result analogous to that obtained with charcoal under the ordinary system is obtained. We must add, however, that in the former case the current of hot or cold air should be longer maintained than when charcoal is used; this prolonged application of hot or cold air in the blast furnace may present inconvenience, which may be avoided by directing the alloys of cast iron with sodium or potassium into a converter, in which they may undergo the final action of the current of air; with this process the working of the blast furnace is the same as in ordinary cases.

"We arrive practically at an assimilation of the coke or coal with alkaline salts corresponding to those furnished by wood charcoal, either by watering the fuel with the alkaline solutions abovementioned, and then allowing it to dry in sheds by introducing the salts into the mass of molten iron, or, lastly, by pouring a concentrated solution of the various salts on the fuel or the ore at the moment of charging the furnace.

"We intend to continue our experiments on the alloys and combinations of sodium and potassium with most of the other metals."

Experiments, instituted with a view to the dephosphorization of the iron from the Königshutte furnaces (Prussia), were made by the introduction of chloride of calcium into the blast furnace, on the theory that chloride of phosphorus might thereby be formed and volatilized. It was, however, found that the chlorine was liberated

from its combination at entirely too low a temperature to effect any change. The results in this country, where fluoride of calcium has been substituted for the chloride, have been much more encouraging, and a decrease in the amount of phosphorus has really been effected thereby, some of it probably passing off in the form of a fluoride. The Prussian iron above alluded to contains 0.497 per cent. of phosphorus, and produces a highly cold-short and brittle Bessemer steel. Refining in a reverberatory furnace by means of jets of air forced down upon the surface of the iron was tried, but led to no favorable result. On puddling the iron and reconverting to cast-iron in a cupola, the percentage of phosphorus was reduced to 0.1. But this reconverted iron was found to be dearer than Cumberland iron delivered at the Bessemer steel works in Silesia, and so this process was abandoned of a necessity. It was also found that iron, when treated in this manner, loses silicon, thereby unfitting it for conversion into Bessemer steel.—*The American Exchange and Review.*

Annealing Pots.—Mr. G. Rose, of Birmingham, makes in the arch or roof of the fire-place or furnace in which the combustion of the fuel takes place, a series of nearly vertical flues. These flues are of a curved figure, and open at top into the annular flue or chamber in which the annealing pot is built or situated, and conduct the flame and products of combustion thereto. Horizontal flues are made in the brickwork of the annealing chamber or furnace, their inner ends opening into the curved or nearly vertical flues passing from the fireplace. The outer ends of the horizontal flues are open to the atmosphere, the amount of air passing through the said flues being regulated by sliding dampers or perforated plates, or perforated slabs. The front of the fire-place is closed by a door perforated with a series of small holes.—*Mining Journal.*

A discovery of extreme importance from a technical and commercial point of view, as well as of great interest to pure science, is that of the recently announced electro-deposition of iron. The iron thus deposited is of great beauty, has a beautiful lustre and a silky texture. No exact experiments have as yet been made on its tensile strength or conductivity. Faithful copies of examples of medieval art of extreme intricacy have already been produced by this means, the moulds used being of gutta-percha, or, in fact, of any material commonly used by the electro-metallurgist for such purposes. The process has also been applied to the production of stereotypes and to a number of other purposes. The material used to furnish the iron is a dilute solution of the double sulphate of the protoxide with the sulphate of potassa, soda, or magnesia, and the apparatus, a battery of low power, usually two small Smee's elements. To Dr. Jacobi, one of the earliest workers in the now fully-cultivated field of electro-metallurgy, we are indebted for this discovery, and the learned experimentalist has already exhibited many beautiful specimens of his art, besides announcing some curious properties possessed by the iron, among which may be mentioned its power of occluding fully twenty times its volume of hydrogen gas. If we accept the very just and well-founded opinion of the late Prof. Graham, that hydrogen is in reality *a gaseous metal*, may not this new form of iron be but an alloy of iron and hydrogenium?—*American Exchange and Review.*

Steel Rails.—A point of some interest has arisen in connection with the use of steel rails on the Great Central Belgian Railway. It is found that steel rails which have been laid resist wear and tear extremely well, but that they acquire such a polish that the action of brakes and the adhesion of engines upon them are seriously interfered with. Experiments upon the subject are being made with a view to the collection of further facts.—*The Engineer.*

Puddling Furnaces.—Mr. J. Halford, Kingswinford, constructs an oven, or combustion chamber, similar in its general form and size to the chamber of the ordinary fire-places; but he makes the bottom of the oven or chamber without fire-bars or other opening for the air, and upon the bottom the fuel to be burnt is supported. The fuel is supplied to the oven or chamber by a hopper at the top, or by an opening at or near the side of the oven. The air for supporting the combustion of the fuel is introduced at an opening in front of the oven or chamber, this opening being at the lower part of the chamber. The fuel is always maintained at such a height as to cover the opening at which the air enters. The whole of the air entering the chamber is thus made to pass through the ignited fuel.

RAILWAY NOTES.

The Fairlie Engine.—A new series of experiments designed to test the powers of the Fairlie Double Bogie Engine, were tried recently upon the first section of the 23½ in gauge Festiniog Railway. An engine of the ordinary construction, but of very small proportions, was tried in competition with the double bogie "Little Wonder." This engine, the "Welsh Pony," made by Messrs. England & Co., had been put into the "stable," and thoroughly overhauled and repaired in anticipation of the trial. The first experiment was intended to show the comparative steadiness and smoothness of motion of the two kinds of engines. The visitors took successively short trips upon the engines. The opinion, in so far as we could ascertain it, was uniformly and strongly expressed in favor of the "Little Wonder." The movement of the "Pony" was, we speak from our own sensations, a succession of hammerings upon the rails, whereas the two bogies enabled the "Little Wonder" to pass as steadily and smoothly round the sharpest curves as in the straightest runs.

The next test was to show the comparative power of the two engines. The "Pony" was yoked to a train of seventy-seven trucks, filled with slates, and weighing in the gross 194 tons. The load was hauled along the embankment at a moderate speed, and for a short distance up the rising gradient on the other side; but at the commencement, or near it, of a gradient of 1 in 90 the "Pony" was dead beat, and the train was backed to the starting point. The engine had next a train of forty trucks attached, but it was found that these could not be taken up the incline, and nine trucks were taken off. The "Welsh Pony" was able to haul the thirty-one loaded trucks satisfactorily. The "Little Wonder" then undertook the test,

and was attached to the same seventy-seven loaded trucks. It whisked them along the embankment and up the inclines with scarcely a check in the speed. The superior merits of the Fairlie engine were on this point also fully admitted. The "Little Wonder" then took up from Portmadoc to Festiniog a train of 125 trucks, seven passenger carriages, and a boat carriage. The train was 380 yards long, and the weight hauled was 114 tons 14 cwt. The distance, just under 14 miles, with a rise of 700 ft., was accomplished in 1 hour 17¼ minutes. Deducting the time of four stoppages, the net running time was under the hour. In some places, between stations, the speed was over thirty miles an hour.

The series of experiments was perfectly successful as regards the merits of Mr. Fairlie's engine, and we have no doubt that the inspection, and the impressions received from it, will do much to encourage the adoption of narrow gauge lines and the Fairlie engine.—*Railway News.*

A Railroad in Greece.—The United States Consul at the Pirœus, Greece, is writing to the "College Courant" a series of letters about Athens. Among the passages which sound oddly to the classical student, from the sharp contrast they present between the ancient and modern city, is the description of a trip by rail from Athens to the harbor. The road is only six miles long, and, though nowise extraordinary, it is a source of never-ceasing wonder to the natives. When it was first opened, the Archbishop was present, and consecrated the locomotive and each car by sprinkling them with holy water. Still the average Greek can not quite reconcile himself to it as any thing in the ordinary course of nature, and when he takes passage he does not cease to cross himself until the motion has become familiar. Every day large crowds of countrymen flock to the depot, and gather on a bridge near by, to watch the train arrive and depart. Could some of their ancestors, who hewed the stone with which the track is laid, revisit their work, or look down upon it from the Acropolis, with what unutterable amazement would they contemplate the approach of a screaming locomotive, without even the poor protective of holy water! Accustomed as they were to the apparitions of gods, demigods, and monsters, this would be a spectacle for which even their mythology could furnish no parallel, and would dumbfound the wise as well as the ignorant. Think of Socrates soliloquizing over a steam engine, Diogenes, with his tub, dead-heading it to the Pirœus, or haggling about a seven-cent ticket, or Euripides working up a railroad catastrophe into one of his polished tragedies, or the courtly Xenophon taking topographical notes for his "Anabasis" from the window of a Pullman sleeping car! These unsophisticated old Greeks, whom we imagine we understand fully, lived in an entirely different world, with which we can have but little sympathy. *Shall some future generation say the same of us?—Iron Age.*

Swing-Beam for Freight-Car Trucks.—That all railway stock should be so constructed as to run with the minimum of concussion between the board and the rail, is conceded by all except the extremely old-fashioned managers, who will not accept any of the the "new-fangled notions," such as safety switches, steel tyres, steel rails, homogeneous boiler plates, etc. It seems that some of the Southern railway managers have got a little ahead of their neighbors in constructing their freight cars with the swing-beam truck, and refuse to allow others of the old-fashioned type run over their roads. In the report of Mr. Fleming, the superintendent of the Mobile and Ohio Railway this matter is thus referred to:—

"As some objections have been raised by connecting roads who wish to exchange freight cars, as to the policy of this company, which refuses to permit any but swinging beam cars to run on the road, the following extract is made from the annual report of 1867:

"'The *truck* is one of the peculiar characteristics of American railways, and, with a few exceptions, is not used in other countries. Its invention was the legitimate result of the imperfection of American tracks, and it was designed to permit the wheels to adapt themselves to the sinuosities of the track, while the line of traction would conform to the general direction of the rails. The importance of these principles is so well recognized that, *without exception, all passenger cars* are constructed practically "centre bearing," and the bodies suspended on the trucks, allowing them to vibrate freely, and the wheels to follow the irregularities of the track.

"'Although these principles are so well recognized as indispensable to safety of passenger cars, they are not generally applied to freight cars, except upon Southern roads. Of the connecting roads who use the swinging-centre trucks, are the New Orleans, Jackson and Great Northern, the Mississippi Central, Vicksburg and Meridian, Selma and Meridian, Illinois Central, and Louisville and Nashville. The experience of this company during the war—when cars from almost every Southern road and of almost every pattern were used—justifies the refusal to permit rigid trucks to be run on the road, even if the plainest principles of mechanics and common sense did not demonstrate the greater safety of the swinging-beam truck.'"—*American Railway Times.*

Knowles's Permanent Way.—We are informed that some portions of the line near Stourbridge which have been laid with the permanent way invented by Mr. Knowles, and which have been subject to severe pressure from the shunting of trains, have given very satisfactory results, and that, as compared with the adjoining timber-sleepered portions of the road, they have been much less influenced by the changes of temperature. In the system of Mr. Knowles wooden sleepers are altogether discarded, and are replaced by nearly square plates of rolled iron, which do not cross the line, so that the near and the off rail remain separate as regards their foundations, and are only united by tie-rods to preserve the gauge. The sleeper plates are 18 in. by 16 in., and are concave beneath from side to side, with bent down edges, convex above, and traversed on the upper surface by a broad groove, with overhanging margins. This groove receives and secures wrought iron jaws or clips, which serve as substitutes for the covered chairs; and the clips are of such size and shape that, when they are pressed closely against a reversible rail, it is suspended between them by its top tables resting on their upper edges, and having no direct bearing on the sleeper beneath. The sleepers are placed opposite to one another, and the tie-rods already mentioned pass through the rails and clips, and

are screwed up by nuts on both sides, so as at once to close the clips firmly and to maintain the gauge of the line. Where there is no joint a single tie-rod suffices between two opposite sleepers; but every joint is placed over the middle of a sleeper, and has a tie-rod on either side of it, besides two extra bolts. The ordinary clips are 6 in. in length; but those at a joint are 16 in. The sleepers, clips, tie-rod, and indeed everything but the top of the rail, is intended to be covered by ballast, and the sleepers would then lie at a depth of about 5 in. from the surface. The merits claimed for this system are, that at a very slightly enhanced original cost it confers greatly increased durability; and, in the second place, that it will give a steadiness of motion that will be conducive both to the comfort of passengers and to the preservation of springs, wheels, and axles—points which it is scarcely necessary to say are of considerable importance in the economical working of our railways.

The directors of the Great Indian Peninsula Railway Company, in their report for the half-year ending the 31st of December last, congratulate the proprietors upon the recent completion, and opening for public traffic, of the main line of this company's railway to Jubbulpoor, whereby through communication by means of the Great Indian Peninsula and the East Indian railways is now established between Bombay and Calcutta, and also with the North West of India. The connection of the Great Indian Peninsula with the East Indian Railway at Jubbulpoor was effected on Monday, the 7th of March last. The detailed estimates of sanctioned works, of unsanctioned works considered necessary and contemplated works, show that to complete the Great Indian Peninsula Railway, 1,272¾ miles in length, with the requisite stations, workshops, and rolling stock (322 miles being double line), the share capital of the Company will require to be increased from the present amount of £17,000,000 to £20,000,000. The capital account to the 31st of December, 1860, showed that £18,700,337 had been expended, leaving a balance of £2,631,774.

New Locomotive.—A correspondent of the "Locomotive Engineers' Journal" describes as follows a locomotive built in the shops of the Louisville & Nashville Railroad, at Louisville, and designed by Mr. Thatcher Perkins, the Master of Machinery of that road:

"The principal feature that strikes the eye at first sight, is the distribution of weight on the drivers, the forward pair coming so far forward that they lap in behind the guides, the yoke or plate holding the guides attaching near the middle. The entire engine, frame, cylinders, rockers, and in fact all the work is much heavier than usual. Mr. Perkins has the past year added largely to the facilities of the shops (which are very extensive) by the purchase and erection of a large amount of improved machinery, and has now in course of construction six new engines for the use of this road.

Changeable Gauge Cars.—The San Francisco "Bulletin" of the 20th ult. announces as follows the success of the experiment made by the Erie Railway in sending a loaded car of changeable gauge through from New York to San Francisco:

"The first through freight car from New York to this city arrived Saturday evening, and was unloaded to-day at the foot of Second street. It is the result of an experiment by Fisk, who intended, if it proved successful, to have a large supply of freight cars constructed on the plan of this one for the transit from ocean to ocean. The feature of the car now here is, that it is mounted on axles on which the wheels can be moved to fit any desired gauge of track. In all devices heretofore used for changing gauge, grooves have been cut around the axle according to the number of changes to be made. It is claimed that these notches destroy the strength of the outside fibres of iron and weaken the axle. The device in this car obviates this difficulty, by inserting a stout feather key laterally on the axle, which secures the wheel at any point on the axle. It extends into the axle about ⅜ of an inch. The inventor of the patent is W. B. Snow, who came on the car. It was built by the Erie Railroad Company, and was freighted with boots and shoes, from Philadelphia, consigned to Hobart & Co., of this city. The trip was made without accident of any kind, and the experiment was pronounced successful. It is stated that the Erie Company will build 1,000 cars for this through trade. The trip was made in 14½ days from New York."—*Railroad Gazette.*

Supplying Locomotives with Water.—The plan of supplying a locomotive with water while in rapid motion, is applied on the Hudson River Railroad, near Peekskill. In carrying this method into practice the company have provided between the rails of the track an open tank or trough, 1,200 ft. long, 18 in. wide, 15 deep, and holding 16,000 gallons of water, supplied from two adjacent springs. The tender is furnished with a pipe having a nozzle pointing forward, and capable, through simple mechanical appliances, of being readily raised and lowered. The train running at full speed (in the first trial of the apparatus it ran at 35 miles an hour), the nozzle is let down so as to pass 2 inches below the surface of water in the trough. As a consequence, the water is forced through the nozzle into the pipe and thence to the tender. The system works so well that a similar apparatus is to be located between Catskill and Hudson on the same line, and it is proposed to establish others at various points between New York and Chicago, which is expected to materially reduce the time required for the trip between the two cities.

This method has been in use in England, where it is known as Ramsbottom's method, but we learn from the "American Artisan" that the inventor was a Mr. McDonald, of Virginia, whose Letters Patent were granted in 1854.

State Railways in India.—Preparations are at last fairly on foot for surveying and staking out the route for the Mhow and Indore Railway, Mr. Crawford Campbell C E, "Superintending Engineer for the Indore and Mhow Railway," having already fixed the point of its commencement by a junction with the Great Indian Peninsula Railway, near Khundwa. The first engineering question of interest connected with the line is as to the place and method of crossing the Nerbudda; but we believe that Mr. Campbell at present expects to find the existing route by the Burwai pass suit him the best, though the gradients of the Simrole Ghaut may require some

special locomotive appliances to work them. The viaduct over the Nerbudda, though of considerable length, will not need to be of great height, as the river there only rises 25 feet. As it is very desirable the line should be as serviceable as possible to the important but now isolated station of Mhow, the route will probably be kept rather more to the westward after passing the Nerbudda, than would have been needful merely in aiming at Indore. After leaving Indore the line is to sweep to the west somewhat, so as to take in the important durbar centres of Rutlam, Jowra, and Mundesor. There will be several ordinary engineering difficulties to be encountered between the junction with the Great Indian Peninsula Railway and H. H. Holkar's capital; but beyond that first terminus, if the line should be carried forward to Neemuch, the work can be accomplished with tolerable facility, the country being level and the watercourses infrequent, though these include the Chumbla and Chumbul. There may be time enough to talk of going on to Neemuch, but this object seems to be a settled purpose with the present Bengali protectors of the Indore line. It is, of course, very important to have that military station and the centre of Rajpootana in direct connection by rail with other military stations on the south or west, and the Bombay merchant will be glad to have railway access thither by way of Malwa rather than be still excluded for an indefinite period.—*Times of India.*

The directors of the Mexican Company state in their report that Mr. Buchanan, their chief engineer, being now in this country, is carefully considering the advantages of Mr. Fairlie's system of engines with a view of determining how far its application may be desirable in the prosecution of the works remaining to be completed.

The Knox and Lincoln Company are to have their track laid from Bath to Damariscotta, and cars running next autumn. A large, substantial and powerful steamer is being built at Bath for their road, to ferry freight and passengers across the Kennebec river at Bath. There are to be seven trestle bridges from Bath to Rockland. At Wiscasset there are 66,500 ft. of piling in 4,000 piles for bridges.

We are informed that a Manchester firm have received an order for some locomotives for a branch railway which is being constructed from the Yeletez and Orel line to Liwny. The locomotives will be on the Fairlie system, with twelve wheels. An English firm will also supply the rails required for the branch, but the carriages and trucks are to be made at Brussels.—*Manchester Examiner.*

Since the opening of the railroad to the Pacific, the price of Panama Railroad stock has fallen from 282 to 140, and its dividends have been reduced from 24 per cent. gold, to 16 per cent. currency.

Great progress is being made with the Punjaub State Railway. Three great iron bridges are to be thrown over the Ranee, the Chenab, and the Thelum, and the iron work is to be ordered in England.

The construction of a southern trunk line is expected to be shortly commenced in the province of Otago, New Zealand. A contract has also been let for the construction of a line between Dunedin and Port Chalmers, in the same province.

ORDNANCE AND NAVAL NOTES.

Another New Gun.—The controversy between Sir Joseph Whitworth and Sir William Armstrong has, for a time, been allowed quietly to drop, and now we have ushered in a new piece of artillery to displace the inventions of both these gentlemen. The breech coil of this gun as it comes from the furnace will weigh 20 tons. The inner coil will be a bar 170 feet long, measuring 6 inches in depth, with a breadth on the upper surface of 5 inches. The magnitude of the operation may be apprehended from the fact that the length of this bar is very nearly equal to the height of the Monument. The coiling up of such a bar while in a state of red heat is a process well calculated to astonish those who are not familiar with such undertakings. The trunnion-hoop will be the largest solid forging ever made. As much as twenty tons of iron will be gathered round the "porter-bar," by which the forging is handled. This quantity of iron will be gradually accumulated, and finally worked *en masse*, the coherence of the whole being secured by the blows of the 15-ton double-acting Nasmyth steam hammer. A trunnion-hoop is, necessarily, a "punched" forging. It is, first of all, made solid, and then, by patience and perseverance, a hole is punched clean through the centre, corresponding in size to the body of the gun. When finally reduced to its proper shape and size by the excision of superfluous metal, the weight of this part of the gun will be 15 tons. In this state it will be a rough forging, and the subsequent process of "turning," by means of gigantic lathes, will reduce it still more. It was intended that the 30-ton gun should only be of 12 inches calibre, and we see that the 35-ton gun itself will go no farther than this, but will probably stop short at 11½ inches. The gun now making at Woolwich is a considerable step in the right direction; but although we go from 25 tons to 35, we are yet far within the limits of our strength.

There is in course of erection, on the east side of New York Bay, a gun that will throw 800 five-ounce balls in one minute to a distance of about two miles. The shot may either be red hot or cold. The gun is circular, and appears like two discs of heavy iron plate about four feet in diameter; upon one side is a funnel to convey the balls through to the proper chamber without cessation of firing or diminution of speed; the muzzle projects upon the periphery of the circular machine, and may be elevated or depressed at the will of the gunner by the trunnion on which it rotates. The machine may be worked by manual labor or steam power, and when worked by the latter it will throw from five-ounce balls to eight pound shot and shell, thus making it a very destructive improvement of warfare. The construction of the gun is under the care of Robert McCarthy & Son, and it was expected that it would be finished in time to test it by July 4.

(We find the above paragraph floating about among the daily and weekly papers. We trust our readers will recognize this dear old gun. The slight modification in detail as given above is not enough to disguise its more important and familiar features. As a revolver among the journals it has failed somewhat of late in frequency and regularity of appearance. During the first years of the war it came around once a quarter.

It will be observed that the old statement, that it could be worked with ease by two men, is omitted in the above description. This, at all events, indicates *some* progress.—ED.)

THE steamship Edinburgh has recently been fitted with compound engines of 275 nominal horse-power, by Laird Brothers, Birkenhead, for the service of the Telegraph Construction and Maintenance Company. Her dimensions are 290 ft. long, 39 ft. wide, and 26 ft. deep; tonnage, 2,200 tons. She is now arranged with three large cable tanks, two of them being 32 ft. in diameter by 22 ft. deep, and the third 26 ft. in diameter by 20 ft. deep. Under the two largest of them there has been fitted an inner skin, forming a double bottom for stowage of water ballast when the weight in the cable tanks has run out. There are also various other fittings and appliances specially arranged for the telegraph work. The engines, which are new, have been made by Messrs. Laird on the compound system, and are the third pair made for the same owners. The Edinburgh's engines are vertical, the small cylinder having a diameter of 44 in., and the large cylinder 78 in., with a stroke of 3 ft. 6 in., and are nominally of 275 horse power. The cylinders are jacketed at the tops and bottoms as well as the sides. The valve for admitting the steam to the small cylinder is fitted with an expansion valve, and is placed at the forward end, and the valve for admitting the steam into the large cylinder is placed between the two cylinders. The pumps are worked by levers from a crosshead on the piston rod of the large cylinder. The condensers have horizontal tubes, the water circulating inside the tubes. There are two cylindrical boilers, firing from both ends, having two furnaces each, with return tubes, and fitted with cylindrical superheaters on the top of each boiler. On the first voyage just completed by this ship from London to Malta, with the cable to be laid from that port to Gibraltar on board, the following results were obtained:—Draught of water forward, 24 ft. 3 in.; draught of water aft, 22 ft. 3 in.; mean, 23 ft. 3 in.; displacement at ditto, 4,870 tons; average consumption per I. H. P. per hour, 1.70 lb.; number of knots per ton of coal, 13.7.

ENGINEERING STRUCTURES.

OPENING OF CONNECTICUT RIVER RAILROAD BRIDGE.—The New York and Boston Shore Line Railroad bridge over the Connecticut River was formally opened on June 11. The length of the bridge is 1,130 ft., and it cost about $225,000. The substructure consists of fourteen column piers to support the stationary spans, besides the abutments at the shore ends, and eleven column piers to support the turn-table and swing span. Each column pier is formed by driving a number of piles in close proximity, covering in the aggregate an area of 5 ft. square. The piles are firmly bolted together; iron cylinders, some 7 or 8 ft. in diameter, are then let down in sections over the piles so as to completely surround them; and the space between the cylinder and piles is filled up with concrete.

The stationary spans are constructed of wood and iron on the truss principle. With the exception of the flooring, which is of wood, the swing span is of wrought iron; it is built on the Pratt style, is 280 ft. long, and can be turned by two men. The bridge will bear a strain of 2,500 lbs. to the running foot; but the breaking weight is estimated at about five times the bearing strain. Although the weather was unfavorable, the opening ceremonies passed off very pleasantly.

THE DARIEN SURVEY.—REPORT OF CAPT. SELFRIDGE, COMMANDANT OF THE EXPEDITION.—Capt. Selfridge, commander of the Darien expedition, who arrived in New York with his flag-ship Nipsic, reported in person at the Navy department. He made a long verbal report of the results of the expedition to Secretary Robeson and Vice-Admiral Porter, and subsequently accompanied the Secretary to the White House, where he explained to the President and the members of the Cabinet the results of the different surveys, and the prospects for the success of the enterprise. The Caledonia and the Morti routes, both thoroughly surveyed by Capt. Selfridge and his party, are pronounced by him as impracticable. The San Blas route, he states, can be made successful. He had not got through with his survey of this latter route when the heavy rain season commenced, and he was compelled to abandon any further progress for the present. Beside this, the entire supplies for the expedition were exhausted. Over 600 pairs of shoes had been worn out by the men, with other clothing in proportion. This San Blas route includes 12 miles of the Bayamo River, which is 18 feet deep at low water, and 28 feet at high tide, with an excellent surrounding country, and also 26 miles of mountains or very high hills. There he was engaged in surveying when he was compelled to give up, on account of the rainy season, exhaustion of supplies, etc. He says there is no doubt but that the canal can be cut through this 26 miles from ocean to ocean, and that the only thing to be now considered is the cost. He says that if this Government feels too poor to undertake the work themselves, they should make a proposition to the great Powers of Europe, and make the canal an International enterprise, with guarantees from all the Powers for its preservation and safety, and each Government to bear equal portions of the expense. Capt. Selfridge's reports and explanations were highly complimented by the President, the Cabinet officers, and Admiral Porter. The President expressed himself much pleased with the results of the expedition so far, and stated that he would recommend to Congress further appropriations for the enterprise, and appeared to think that this country should do all the work itself, and take all the benefits. Capt. Selfridge was relieved from the command of the Nipsic, and ordered to Portland, to prepare for the renewal of the survey next Fall. The steamer Guard is on her way home to Philadelphia, and the steamer Nyack has gone to Panama. These, with the Nipsic, comprised the fleet. Capt. Selfridge states that he lost one man by drowning, and three by desertion, and that the general health of the fleet, officers and men, was excellent, considering the disagreeable rainy season.—*N. Y. Tribune.*

THE NEW PIER AT CARDIFF.—The low-water pier recently completed at Cardiff was constructed by the trustees of the Marquis of Bute, Mr. J. MacConnochie being the engineer. It was commenced in August, 1867, and during the following year all the piles carrying the superstructure were driven. These piles are of Memel timber, placed 24 ft. apart, and with 6 piles transversely in each row. The total length of the pier is 1,350 ft., and its breadth 34 ft. 6 in., except at the head, where the width is increased to 100 ft. The roadway. 10 ft. above the level of spring tides, is carried upon wrought-iron girders, which extends from end to end of the pier in two rows. The roadway consists of planking, and a timber fence extends on both sides for the whole length of the pier, except at the landing stages, where chains are substituted. The platform is divided into a footpath for passengers and a space for vehicles, while a railway runs along the whole length to the pier head. The passenger landing stage is a pontoon 80 ft. long and 30 ft. wide, rising and falling with the tide, and connected with the pier by a flight of steps and landings at different levels. Over the pontoon is built a railway station 108 ft. long, and 20 ft. high, with waiting rooms and office, and immediately adjoining is a tower 40 ft. high carrying a dioptric light. Beyond the station, sidings to facilitate loading and unloading vessels, are laid, a traverser extending across the pier, for connecting the main line with the sidings. At the end is placed a 10-ton hydraulic crane worked from a large engine close to the East Dock basin. A lift also is provided for raising passengers or their luggage from vessels alongside.

At present the extension of the line from the pier connects only with the Rhymney Railway, and trains run through to the Adam street station, but other junctions will subsequently be made.

NEW BOOKS.

THE SCIENCE OF BUILDING: an Elementary Treatise on the Principles of Construction especially adapted to the requirements of Architectural Students. By E. WYNDHAM TARN, M.A., London, Architect. Illustrated with forty-seven wood engravings. London, Lockwood & Co. For sale by Van Nostrand.

Mr. Tarn has well described the scope of his work in his preface, where he says that he "has endeavored to introduce the student of architecture to a general outline of the scientific subjects connected with his profession, an acquaintance with which can at present only be obtained by the perusal of a large number of works by various authorities." He further states that in compiling his treatise, he "has been careful in all cases to consult the writers who stand highest in their respective branches of knowledge; and by avoiding the use of the higher mathematics, as well as those topics which belong more especially to the engineering profession, he has brought the various subjects within the capacity of those whose mathematical attainments do not extend beyond elementary geometry and algebra."

To say that Mr. Tarn has carried out the programme laid down in his preface would, however, be rendering him very scant justice. In reality his book is very far from being a mere compilation; it is an able digest of information which, as he truly remarks, is only to be found scattered through various works, and his book in fact contains more really original writing than many putting forth far stronger claims to originality.

The book commences with a comprehensive and clearly-written chapter on "Mechanical Principles," in which our author treats of the composition and resolution of forces, diagrams of forces, moments, centre of gravity, stability of walls, strains on beams, and other kindred matters. This is followed by a short chapter on "Retaining Walls" which is in its turn succeeded by one on semicircular, segmental, elliptic, Gothic, and oblique arches and cupolas. In this chapter Mr. Tarn has managed to deal with an abstruse subject with as little complication as possible, and, moreover, the somewhat lengthy formulæ, which have unavoidably been introduced here and there, are illustrated by examples which will materially assist their application by the student. We notice that in this chapter the author has given a digest of some interesting investigations of his own, relating to Gothic arches and vaulting and the stability of domes.

Leaving theory for a time, Mr. Tarn next treats of the materials employed in construction; and his fourth chapter is devoted to a description of the principal natural and artificial stones and their qualities. The fifth chapter deals with timber, commencing with some remarks on the growth of trees and the decay to which wood is liable, and passing on to consider the strength of different varieties of timber, the strength and deflection of wooden beams, the strength of pillars, the framing of roofs, and centrings for arches. Next we have a chapter on cast and wrought iron and steel, containing information relating to the strengths of cast-iron beams and columns, the strength and deflection of wrought-iron beams and girders, strains on roofs, etc.; the information afforded on these matters being just that which an architectural student requires.

The last chapter relates to data concerning water in vessels and pipes, such as rules for calculating the pressure on the sides of tanks, the flow of water through pipes, etc. Somewhat to our surprise, we came upon a paragraph in this chapter relating to specific gravity, and the mode of ascertaining it. At first we considered this paragraph out of place; but we must own that after looking over the book again we are unable to suggest a more suitable position for it; unless, indeed, it was placed in the appendix, which contains a lengthy table of the specific gravities and weights per cubic foot of all the principal materials used for building purposes.

Altogether, Mr. Tarn has done his work exceedingly well, and he has produced a book which ought to earn him the thanks of all architectural students. To the publishers, also, a word of praise is due. The book is clearly printed in bold type, the wood-cuts are all well executed, and the work has been made of a very convenient size for reference.—*Engineering.*

THE FUEL OF THE SUN. By W. MATTHIEU WILLIAMS, F. C. S. London: Simpkin, Marshall & Co. For sale by Van Nostrand.

We have in the work before us a proof that a very interesting and readable volume may be produced, although the hypothesis which has called it into being may be one with which we do not agree. Mr. Williams discusses at greath length the very

perplexing question of the sun's fuel, nevertheless we do not think that his hypothesis is an improvement upon that of Helmholtz and Thomson. But let us hear the writer speak for himself. After having come to the conclusion that an atmosphere very similar to our own, but only more attenuated, pervades all space, he supposes that the sun, in its progress through space, encounters new portions of this atmosphere, and then asks the following question: "Does there exist in the actual arrangements of the solar system any machinery for stirring in an important quantity of the new atmospheric matter and ejecting the old? If so, the maintenance of the sun's heat may be fully accounted for." The question is answered in the affirmative; the atmosphere is supposed to be the sun's fuel, and the planetary attendants of the sun are supposed to perform the duty of stokers with untiring vigilance and efficiency. The mode of action of this atmospheric fuel in furnishing heat is supposed to be as follows: "It is evident, then, that the first result of the great evolution of heat from mechanical condensation of the mixed atmosphere of aqueous vapor, carbonic acid, and free oxygen and nitrogen, will be the dissociation of the water and the carbonic acid. But there must somewhere be a height at which the temperature capable of effecting dissociation terminates; where the atmosphere of elementary gases fringes upon that of combined aqueous vapor, and where these separated gases must revert into reunion with a furious chemical energy which will be manifested by violent combustion. Thus we shall have a sphere of dissociated gases and a sphere of compound vapors separated by an interlying stratum of combining gases, a spherical shell of flame, constituting exactly what solar observers have described as the 'photosphere.'" In fine, Mr. Williams' hypothsis is "a perpetual bombardment of 165 millions of millions of tons of matter per second without in any degree altering the density, the bulk, or any other element of the solar constitution."—*Nature.*

EINLEITUNG IN DIE PHYSIK. Bearbeitet von Professoren G. KARSTEN, F. HAEMS, und G. WEYER.

The volume before us is introductory to the "Allgemeine Encyclopädie der Physik," which is in course of publication, under the general editorship of Professor Karsten. The authors endeavor to supply whatever would not naturally be found or expected in the separate treatises of which the Encyclopædia is made up, which have been written independently by specialist authors from their individual points of view. They add a systematic treatment of everything that may be considered auxiliary to the entire group of the physical sciences.

Professor Harms is the author of the most important part of the work—a philosophical and historical introduction to the whole subject. The discussion ranges over three principal heads:

1. What are the proper limits, and the true relations of physical science, and what distinctions can be drawn between it and the other sciences of matter?

2. What are the methods of physical inquiry, with a critical estimate of induction, of speculation or deduction, and of the theory of cognition (Erkenntniss-theorie) which has arisen in Germany since the days of Kant. This discussion is naturally conducted both historically and metaphysically. The rapid but exhaustive reviews of Bacon, Locke, Hume, Sir J. Herschel, Mill and Whewell—the only authors quoted on the subject of induction—will be specially interesting to English readers.

3. The philosophical basis of the conceptions at the root of the natural sciences, with a full treatment of Idealism and Materialism, and a discussion of the differences between matter passive and without force, and matter active, bound up, that is to say, with capacities of change of state.

Professor Karsten's contributions involve an enormous amount of statistical and bibliographical labor. Fifty pages are occupied with a complete catalogue of the literature of general physics. All the encyclopædias, all the scientific periodicals and collections, all the books on the history of science, and all the handbooks and general treatises of all modern nations, are gathered together in one most useful and naturally bewildering list. Germany, Switzerland, England, the United States, France, Belgium, Holland, Denmark, Sweden and Norway, Russia, Italy, Spain and Portugal, are the countries which contribute. The order in which we have given them exhibits the civilized world from the German professor's point of view.

A second treatise by the same author deals with all of what are called the universal properties of matter, and discusses in full the problems of chemical affinity and the newest theories of atoms. Little is really carried lower than the year 1860, but references are given to all books of importance published as late as 1867.

His third treatise gives us the methods of measurement, with full descriptions of the instruments and copious tables of comparison between the units of different countries. Professor G. Weyer finally supplies a separate work on the determinations of space and time. All questions of latitude and longitude, of apparent and real magnitude, are fully discussed, and the astronomical data which affect our estimates of time are exhibited in full.

We have preferred to give our readers a simple statement of what is contained in the closely-printed volume of 900 royal octavo pages before us. Detailed criticism of five separate treatises, in the space at our disposal, is a mere impossibility. It is sufficient to say here that every subject discussed is worked out in all the painstaking and exhaustive detail to which the separate volumes of Karsten's Encyclopädie previously published have accustomed us. Such works are of the greatest possible service to literature. They are not produced in England. Our scientific men are too busy conquering new worlds, and lecturing on the exciting incidents of every fresh conquest. There is not a man too many thus engaged, but we confess that we sometimes turn with desire to our two great mediæval universities, where the liberality of our forefathers has established hundreds of fellowships, expressly that men might have leisure to devote themselves to life-long studies. How is it that Oxford and Cambridge leave us to sigh for impossible translations of laborious books like this which has been sent us principally by the University of Kiel?—*Nature.*

THE SLIDE VALVE PRACTICALLY CONSIDERED. By N. P. BURGH, Engineer. Third Edition. London: E. & F. N. Spon.

It is quite unnecessary for us to enlarge upon the important position which the slide valve occupies among steam-engine details, or to urge the

necessity which exists that all engineers engaged in steam-engine construction should thoroughly understand the action of such valves, and the effects attending variations in their dimensions. These matters being of acknowledged importance, it is but natural that we should be disposed to regard favorably any treatise professing to deal practically with the subject of the slide valve and its proportions; and we, therefore, commenced our examination of the work before us in the full hope of finding it a book which we could conscientiously recommend to engineering students, and, in fact, to all in want of information on the subject with which it deals. In this hope we were strengthened by the fact that the book had already reached a third edition, and by the statement made in the preface, that this third edition had been rewritten and extended. Much to our regret, however, we find the work to fall very far short of what we conceive that such a treatise should be, for although it probably contains but few actual misstatements, yet it is greatly wanting in that clearness and precision so pre-eminently requisite in a book dealing with the slide valve and its action. In fact, the impression left on our minds by a perusal of the work is not, perhaps, so much that Mr. Burgh is ignorant of the subject on which he writes, as simply that he entirely lacks the power of communicating his knowledge in clear and easily comprehensible language; while, moreover, he is far too much inclined to substitute descriptions of particular examples in the place of explanations of general principles capable of universal application.

Of locomotive practice Mr. Burgh says nothing, neither does he distinguish in any way between the proportions required for the valves of fast running as compared with slow running engines. A variety of other matters with which a treatise on the slide valve ought to deal are likewise left unnoticed, and altogether the work requires to be enlarged and, above all, entirely rewritten. At present it is little more than a prolonged enigma.—*Engineering.*

MARVELS OF ARCHITECTURE, translated from the French of M. Lefèbre. To which is added a Chapter on English Architecture. By R. DONALD. London: Cassell, Petter & Galpin. For sale by Van Nostrand.

This is a pretty little book, very readable and likely to interest many in what architecture has done. It is not intended for the professional student. The chapter on English architecture is the least satisfactory part of the volume, and further confirms what we recently said as to its being desirable that persons who write about buildings should know something of architecture. Take an instance in proof. The author is speaking of "the Gothic style of architecture which sprang into ascendency during the Middle Ages," and says:

"The style is also widely known as the *Pointed* style of architecture, and is very largely to be found in the *Saxon and Norman* edifices of this country. What is known as the *Corinthian order* of Pointed Architecture is, indeed, almost peculiar to England."

Very peculiar, indeed, we should say. Again:

"Though the Gothic and Pointed styles are often confounded, there is considerable distinction between them. In Gothic, the general running lines are horizontal, as in entablatures and single cornices; in Pointed, the general running lines are vertical."

The author is evidently at sea. Nevertheless, it is an interesting little book; and it includes a considerable number of illustrated wood-cuts.

ELEMENTS OF SURVEYING AND LEVELLING, WITH DESCRIPTION OF INSTRUMENTS AND THE NECESSARY TABLES. By CHARLES DAVIES, LL.D. New York: Barnes & Co. For sale by Van Nostrand.

This new work is the result of a complete revision of the "Elements of Surveying and Navigation," by the same author, a work which has held for many years the foremost place among our text-books upon this branch of science.

Of late, however, there has been a demand in our higher schools for instruction of a more technical character, adapted to the wants of those pupils who designed to assume somewhat responsible positions in scientific pursuits.

This demand has been meagrely supplied, so far as the different branches of surveying is concerned, by Engineers' Table Books, which, although well designed for the wants of engineers in ful practice in the field, were illy adapted to the use of the learner of the rudiments.

We find in this new work all that can be asked for in a text-book. The following synopsis of a few chapters will verify our statement:

In the trigonometrical examples in the first sections, regard has been paid to the problems most frequently occurring in ordinary practice, and the methods of solution are those which custom at least has sanctioned.

In plane surveying, the methods of holding the chain, chaining up hill sides, distributing the work in a full party, or a small one, keeping the notes, distributing the error of balances, are all set forth in the most satisfactory manner.

In railway curves, an outline of the different methods of calculating and locating the circular curves is given. Besides, the "deflection method" in general use, there are given the methods involving the use of the chain only, some three or four in number, and the method which requires two transits and no chain.

In section levelling, the methods of the railroad engineers are fully explained. The reconnaissance, the establishment of the route, the field operations, use of *benches and turning points*, taking and reducing the notes and establishing the grade-line, are treated each in proper order.

This is naturally followed by cross-section leveling; and in this chapter much useful instruction will be found which has never appeared in the books before. Twelve pages are devoted to the method of setting slope stakes. The diagrams are numerous, and all possible cases of excavation and embankment are covered by the method explained.

The rules for the field operations and recording the notes are given in italics. The leading methods of calculating the earthwork are each applied to an example.

The section on mining surveying ends the work. In this, as in the preceding chapters, the instruction is of a thoroughly practical kind; two or three excellent illustrations aid the text. If there is anything in the few works on sub-surveying as well adapted to the student's wants as this chapter, it has escaped our search for it.

There are other sections, which we have omitted, which deserve mention, but the above synopsis will give the reader a fair idea of the value of this new text-book in surveying.

DIE SPECTRALANALYSE IN IHRER ANWENDUNG AUF DIE STOFFE DER ERDE UND DIE NATUR DER HIMMELSKORPER. Von Dr. H. SCHELLEN. 1 vol. 8vo. Brunswick. 1870. For sale by D. Van Nostrand.

The author is director of the "Realschule" of Cologne, and has produced an admirable compilation, in which, with scientific sequence, everything of importance up to the present time on the nature, use, applications, and discoveries so far due to spectrum analysis, are given, along with a running commentary as to the history of the method itself, not forgetting those to whom it is chiefly indebted, even to the extent of giving some of their portraits. It is a very real and practical book, though so well illustrated with wood-cuts, two spectrum plates in color printing, and four portraits, as to have some pretensions to be claimed as a work *de luxe*. Spectrum analysis has no doubt already elicited marvellous results, and takes captive the imagination by the prospect it offers of questioning the stellar bodies and spaces far beyond all other as yet known means of chemical inquiry.

But although it is in the hands of men of far higher knowledge, and of exactive science, and, on the whole, of far soberer views than are the glacial geologists generally, there is some danger that this new Pegasus, when launched fairly out into the celestial spaces may run away with its riders. Some recent retractations of recently assumed discoveries by this method of new elements, even in things that we can reach and handle, ought to inspire a wholesome caution and reserve as to the things in heaven, as visible to spectral philosophers and in their methods.

METEOROLOGY. By Sir John F. W. Herschel, Bart. From the Encyclopædia Britannica. Second Edition. Edinburgh: A. & C. Black.

INTRODUCTORY TEXT-BOOK OF PHYSICAL GEOGRAPHY. By D. Page. Fourth edition. Edinburgh: W. Blackwood & Sons. For sale by Van Nostrand.

We class these two books together as new editions of standard treatises in their respective departments of science that are among the best that can be used by students or teachers. The term "Meterology," which has entirely lost its etymological meaning, is defined by Sir John Herschel as "the description and explanation of those phenomena which group themselves under the head of the weather, of the seasons, and of the climate,' a branch of natural science of the laws regulating which we are at present almost entirely ignorant, as Dr Balfour Stewart has shown in these pages. Writers on physical geography content themselves at present with a description of the physical contour of the globe, with some slight reference to its climatology, and the distribution of its animal and vegetable life, Mrs Somerville's handbook being, as far as we know, the most complete in this respect. The better and more logical mode would seem to us to be, first of all to treat of the earth as a member of the solar system, and thence to deduce the laws which govern its natural phenomena; we believe that in this way such phenomena as those of ocean currents and trade winds, and the variations of climate, would be rendered far more quickly intelligible to the learner than is now the case. From his stand-point, Dr. Page's "Introductory Text-Book" discusses the subject in his usual clear, concise, and systematic manner.—*Nature.*

RUSTIC ADORNMENTS FOR HOMES OF TASTE. By Shirley Hibberd. New Edition. London: Groombridge & Sons. For sale by Van Nostrand.

That two editions of this book have been disposed of in a short time is ample justification for the publication of a third, especially when got up in so handsome a style as the one before us. Works of this kind appeal to a large public, not over-critical as to scientific accuracy but glad to possess that amount of knowledge which enables them to talk about ferneries and aquaria without committing any egregious blunder. We are far from depreciating the value of this smattering of science where it is all that opportunity permits to be attained. Those who like their homes to be surrounded by beautiful natural objects will here find a large fund of information respecting the aquarium, the fernery, the aviary, the apiary the conservatory, etc., given in a pleasant style, illustrated with wood-cuts and colored plates. The volume makes altogether a very pretty gift-book, especially for a young lady.

OTHER WORLDS THAN OURS: The Plurality of Worlds Studied under the Light of Recent Scientific Researches. By RICHARD A. PROCTOR, B.A., F.R.A.S. Author of "Saturn and its System," etc. London: Longmans, Green & Co., Paternoster Row. For sale by Van Nostrand.

A new work from Mr. Proctor's pen is hailed by all interested in the science of astronomy. Mr. Proctor's subject is most interesting, and he has produced a very readable book, which will prove attractive alike to scientific and non-scientific readers. Speculations as to the conditions under which beings like ourselves would exist if inhabiting the planets, have often been brought forward; and Mr. Proctor has here treated the matter in the same careful and exhaustive manner which characterized his work on "Saturn and its System." . . . We heartily recommend the perusal of this volume to every lover of the science of astronomy. Unlike many scientific works, a tone of reverence towards the Creator of all things runs through the book, which is greatly to be commended.—*Astronomical Register.*

LECTURE NOTES FOR CHEMICAL STUDENTS. By EDWARD FRANKLAND, F.R.S., Professor of Chemistry in the Royal School of Mines. Vol I., Inorganic Chemistry. Second Edition. London: Van Voorst. 1870. For sale by Van Nostrand.

We are glad to see that Dr. Frankland, in bringing out a new edition of his excellent "Notes,' has divided the work into two parts, corresponding to the inorganic and organic divisions of the science. To the great mass of students this arrangement will be a boon. The alterations in the present edition are not numerous; but such as they are we must confess that they appear to us to be in the right direction. Notably would we point to the fact, that Crum Brown's graphic formulæ have been deprived of their circles, for it leads us to a hope that in the third edition they may be improved out of existence. We certainly, contrary to Dr. Frankland and other high authorities, deprecate the em-

ployment of the species of diagrammatic guesswork involved in the use of graphic formulæ. We believe that its influence over the student is as irresistible as it is pernicious, and we trust that ere long the development of a more positive school of chemistry may lead to its banishment from our books. Apart, altogether, from the fact that chemical bodies undergo their metamorphoses in a definite relation to certain figures which represent weight, we know nothing of atomic constitution, and such a thing as an atom is just as great an impossibility as the idea of a big wall limiting space and closing in the universe. Indeed the dogmatism of certain chemists on this question reminds us of the curious archetype plans which some biologists would have us believe a creator set before him, lest he might make a mistake in cutting out the manifold patterns of animal life. Such things result from giving a false realism to mere dreamy and pleasant speculation; but they are out of keeping with true philosophy; and, with the help of a little more positivism, the study of phenomena will soon drive the graphic formulæ into the "curiosity shops" of chemical science.—*Scientific Opinion.*

MISCELLANEOUS.

Union Pacific Engineering.—The article in our June Magazine bearing the above title should have been credited to the "Chicago Railway Review" instead of the "Iron Age."

New Method of Rapidly Drying Timber.—What is required to be done in order to effectually dry timber? In the first place it is indispensable that all the soluble particles within its pores be removed, or otherwise it is manifest that they will always constitute a cause of dampness and deterioration. They would, in fact, act as a sponge, and absorb and retain a considerable proportion of humidity. By the method to which we draw attention, the soluble matters are first got rid of, and then the drying process thoroughly effected. The operation is commenced by allowing the timber to steep in boiling water for several hours, which removes all the soluble ingredients. At the lapse of this time it is dried, and again steeped or boiled in a weak solution of borax. The object of this is to remove the albuminous particles which will not dissolve out by the simple action of water, like the other more soluble ingredients. The action of the borax, however, produces this desirable result, and the albumen is then got rid of. The final step consists in removing it to a drying room heated by steam, where it remains during three days, at the termination of which it is perfectly dry. In France there are several large establishments for carrying on this drying business, and as the French employ more timber in permanent, or intended permanent buildings and erections, than ourselves, the workshops are kept generally very busy. It may be impossible to prevent the use of green timber, dating it from the time of felling, but it is not impossible to adopt some method of preparing it that shall prevent the wood of the floors, doors, and windows of houses two years old "gaping" in the face of their proprietors or tenants, as the case may be.—*The Building News.*

Economic Production of Oxygen.—The production of oxygen on an economical system for industrial purposes, as well as for illumination, is a task upon which many chemists in France and elsewhere are engaged. M. Delaurier has given much attention to the manufacture of manganate of lime in connection with this subject. This manganate may be produced by heating together any of the oxides of manganese reduced to powder with an equivalent of slacked lime or chalk, also in powder, the two being carefully mixed together and heated to redness in contact with the air, the mixture being continually stirred or turned over, so that the absorption of the air may be complete. This composition is insoluble in water, it is formed much more easily than the manganate of soda and potassium from manganese and soda and caustic potash, because these manganates, being to a certain degree fusible, present smaller surfaces to the air for oxidation. The process indicated above has the advantage of furnishing at small cost a composition which serves in the production of oxygen for the oxyhydrogen light by the ordinary process, and also as a very powerful agent of oxidation in laboratory operations. The oxygen may also be obtained by the use of an equivalent of sulphuric acid which deposits the lime in the form of sulphate mixed with hydrated protoxide of manganese; two equivalents of oxygen are the result of this process. The manganate of lime is manufactured very economically by employing the salts of manganese, which are wasted in many industries.

Tenacity of Cast Iron.—A Hanoverian engineer, Mr. Hagen, has given his attention to the loss of tenacity in iron castings caused by inequality in cooling, and the following are the results at which he has arrived:—Having observed that the solidity of castings did not depend solely on the observance of the known laws of the strength of materials, but also on phenomena connected with casting and cooling, and having called to mind the fact that it was frequently noticed in the foundries that castings intended to support great weights showed, on being taken out of moulds, cracks or faults, or at least exhibited them after having been submitted to slight shocks. Mr. Hagen generally attributes these accidents to interior tension within the casting, or to another phenomenon, supposed to consist of a kind of suction, which, like the tension, results from differences in withdrawal from the mould and cooling. Thus in the thin parts of small section, and in those which are salient or flat, the diminution of temperature is more rapid than in the solid portions of a casting, or in those which are nearer to a great mass of the metal, or, lastly, which form retiring angles. The metal, which is in contact with the cold, damp mould, a conductor of caloric, also parts with this fluid much sooner that that which is only in contact with warm materials and bad conductors. Further, the molten iron, in passing through the get and the mould to reach the parts most distant from the tap-hole, transmits a portion of its heat to the surfaces with which it comes in contact, and cools sooner than that which remains near the get or in the neighborhood of surfaces heated previously by the passage of other metal. The effects of these causes and irregularities, says Mr. Hagen,

soon show themselves; those parts most rapidly cooled contract and causing a vacuum by the diminution of their volume, exercise a kind of suction on the neighboring metallic molecules. If the latter are still fluid, or, at any rate, have preserved sufficient heat to allow them to yield, there is no fear of tension, but, if the casting in those parts is solidified and incapable of yielding, the opposing forces acting within the casting must destroy or, at least, diminish its tenacity. These views are not very different from those held by most engineers in this country.

THE COMPOUND MARINE ENGINE.—A correspondence is published in the "Mail" between Mr. Charles Randolph, late senior partner of Randolph, Elder, & Co., and Mr. John L. K. Jamieson, at present representing that firm, relative to the invention or introduction of the compound marine engine. It appears that our contemporary had ascribed all the merit to Mr. Randolph's partner, the late Mr. John Elder, and Mr. Randolph calls upon Mr. Jamieson, to whom the article had been submitted prior to its publication, to put the matter right as regards his own claims in connection with the improvement in question. Mr. Jamieson declines to say "what proportion of merit should be divided between the partners," on the ground that he cannot do so "from his own knowledge." In justice to himself Mr. Randolph accordingly publishes the correspondence, which he closes with the following statement:—"I have no hesitation in affirming—First, that I alone originated the combined engine applied to marine purposes as made by Randolph, Elder & Co., arising out of my knowledge and experience of the superior economy of our double-cylinder factory engines as compared with marine engines in consumption of coal. I affirm secondly, that the designing of those engines was in great measure done by me; and, thirdly, that Mr. Elder on several occasions proposed to give up the making of the combined engine, and go back to the older but more wasteful forms of engine, rather than continue to combat the difficulties and uphill work of bringing it into general practice—which I am pleased to say is now the only engine generally adopted for marine purposes." Disputes of this kind are always more or less unpleasant; but "honor to whom honor is due." Mr. John Elder would have been the last man to claim any distinction which did not properly belong to him, nor would Mr. Randolph detract unfairly from the unquestionable merits of his deceased partner and friend. Suffice it that both gentlemen wrought well together during their prosperous business connection, and that the firm attained, through their united labors, with the zealous co-operation of the third partner of the firm, Mr. R. S. Cunliff, a great reputation among the ship-building and engineering firms of the world.—*Glasgow Citizen.*

SEWAGE OF ALDERSHOT—Mr. Rawlinson's report on this subject lately issued contains some points of much general interest. He states that "as an agricultural experiment, the Camp Sewage Farm is a success, land having no agricultural value in its natural state having been made (with the sewage) worth a rental of £25 per acre per annum; the cost to bring the land to this state, breaking up the subsoil crust, washing out the protoxide of iron, levelling the surface, and forming the sewage carriers, having been about £50 per acre, and occupying some three years of time." This farm consists of 89 acres, and has been in course of formation and cultivation during five years. The sewage of a population of 8,000 persons, "with about 200,000 gallons of water, passes through the land by means of irrigation, and though the statement is sufficiently shocking from a sanitary point of view, there is yet strong testimony to the efficacy of this method of deodorization in the recorded fact that the people break down the fences in order to get to the drain-ends—that is to the extent of the subsoil drains—to obtain this water for household use. Mr. Rawlinson does not, of course, mean to imply that the water is fit for drinking when he says "the whole sewage passes through the land under cultivation, so as to be clarified and disinfected, no portion of it flowing over the land, or leaving the land otherwise than by the subsoil drains, where it issues bright and sparkling."

FRENCH EXPERIMENTS WITH LIQUID FUEL.—For more than 10 years M. H. St. Clair Deville has been experimenting with mineral oils as fuel. "Comptes Rendus" and "Le Journal de l'Eclairage au Gaz" have lately published some interesting facts in regard to these experiments, a *resumé* of which is our present purpose.

The oils employed have been obtained from various natural sources, and the experiments have also included the heavy oil from the Parisian Gas Company's works.

The experiments have determined the following points: In 12 kinds of crude oils analyzed, there was found to be from 82 to 87.1 per cent. of carbon, 7.6 to 14.8 per cent. of hydrogen, and 0.9 to 10.4 per cent. of oxygen.

The heavy oil of the Parisian Gas Company has a specific gravity at 32 deg. Fahr. of 1.044, and at 88 deg. Fahr. 1.007. It is of a dark brown color, and contains 82 per cent. of carbon, 7.6 per cent. of hydrogen, and 10.4 per cent. of oxygen, nitrogen, and sulphur. Heated to 424 deg. Fahr., only 12.5 per cent volatilizes. It remains fluid at 12 deg. Fahr. A tun of it contains about 220 gallons, and its cost is about 50 francs per tun, or in round numbers 10 dollars in gold, our currency.

The amount of carbon added to the hydrogen contained in this fuel, must make it a very powerful heat-generating combustible. It has nearly the lowest expansibility of all the oils, its coefficient of expansion being 0.000743, and the lowest coefficient being 0.000652.

The most important experiments with the heavy oil were made with a locomotive of the Strasbourg Railway Company. This locomotive has uncoupled wheels and outside cylinders. Its weight is 20 tons, and that of the tender is 15 tons. It has a heating surface of 72 sq. yds.

The oil was supplied to the furnace from a tank, being fed by its own gravity. An additional supply was carried on the tender, wherewith to renew the supply in the tank as required.

The fire was kindled by lighting some shavings and sticks on the floor of the fireplace and at the same time admitting a small quantity of oil. A jet of steam was sent into the smoke pipe from the blow-off pipe of another engine, to increase the draft. It took an hour and a quarter to get up steam, during which time 11 gallons of oil were consumed. It was shown, however, that by consuming 12½ gallons of oil, steam could be got up in two and one half hours, without assistance from

another engine, but with the inconvenience of a large amount of dense black smoke.

On the first experimental trip it was found that a speed of 40 miles per hour was obtained with a consumption of about 14 lbs. of oil per mile.

In a second experiment a train of 70 tons was drawn at a speed of 40 miles per hour, with a consumption of about 17 lbs. of oil per mile.

Subsequent experiments gave results not differing essentially from those mentioned.

The grate consists of 20 bars of iron cast in one piece, with channels for the oil to run down, and it is set perpendicularly before the furnace, which is lined with fire brick. A separate cock supplies oil to each grate bar.—*Scientific American.*

FEATHERS IN MAHOGANY AND OTHER WOODS.—We have been asked by a correspondent for an explanation of the so-called "feathers" in the grain of mahogany, satin-wood, etc.; thinking other of our readers who have to do with woods may be interested in the subject, we offer the following explanation:

In the structure of all woods used in building, there is, firstly, a series of vessels of woody tissue surrounding the heart of the tree, having a *vertical* growth, and arranged in *annual concentric circles;* secondly, there are certain hard woody growths, called the "medullary rays," *radiating* from the heart, and consequently more or less *horizontal:* these vertical and horizontal growths are intimately but *regularly plaited and intertwined together,* to give strength to the trunk, and thus far all is regularity. Now, where the branches burst through the stem, this regular arrangement is upset, and the above-mentioned woody vessels are disarranged, and pushed at different angles. When the tree is cut down and sawn horizontally across amongst these branches, these disrupted horizontal and vertical vessels (of different colors, be it remembered), are seen cut at every conceivable angle, and an ornamental "feather," more or less extensive, is the consequence. These feathers do not exist at the *base* of the tree, because there are no branches there to disturb the annual growths of the wood (minute feathers do indeed exist at the *very heart,* and these were caused by the growth of leaves and twigs when the tree was a seedling or little cutting). "Feathers" are not seen in *deal* because the fir is a straight-growing tree, without branches, in the portion of the trunk used in commerce. "Feathers" are seen most abundantly in "pollards," for the simple reason that after the top of the tree has been sawn off, an immense growth of branches is always induced, disturbing the tissues in every imaginable way, the action of the *light* on the "feathers," adds greatly to their beauty after the wood is polished.—*The Builder.*

TEMPLE OF MINERVA POLIAS PRIENE, ASIA MINOR.—The newspapers have mentioned that a valuable collection of ancient marbles, the result of excavations by Mr. R. Popplewell Pullan, to whom the readers of the "Builder" have often been indebted for accounts of foreign cities, was on its way to England, and would be placed in the British Museum. The cases have now arrived and are being unpacked. They contain fragments of the sculptural and architectural adornments of the temple, including portions of the celebrated statue of Minerva, mentioned by Pausanias, a colossal female head of a fine period, parts of several draped statues, heads of the Macedonian time, and fragments of the frieze, which in style closely resembles the reliefs on the Mausoleum, and is believed, in fact, to be by the same hand. Besides the marbles discovered by Mr. Pullan, there are 33 cases, the fruits of the labors of Mr. Wood at Ephesus, and 2 cases sent from Asia Minor by Mr. Dennis, whose researches among the tombs of the Lydian kings at Sardis were abruptly brought to a close by the want of funds.

Mr. Pullan has been engaged in excavating ancient sites with varying results, at different times, during the last 8 years, at considerable risk, and may be congratulated on the result of his last undertaking. The temple as uncovered presents an octostyle plan; the steps and pavements being everywhere perfect. The walls of the naos and pronaos are standing in some places to a height of 6 ft., and the columns of the porticos to a height of 13 ft. or 14 ft. The whole is built of white marble, put together with iron cramps and copper dowels, and without mortar, and all the carved ornaments are of the most elegant workmanship. There is no other ruin in Asia Minor of a good date in so perfect a condition. The temples of Arzani and Euromus, which alone are more complete, are of a much later period. The site is a magnificent one, being on the side of a mountain, above the plain of the Mœander, and opposite the marshes which surround the site of Miletus. At the time when Mr. Pullan encamped on the spot, three-fourths of the population were suffering from intermittent fever, and before he had been at work long he and his principal workmen were attacked by it. He was compelled to suspend operations. The wintry storms were so violent, that their encampment was blown down, and he was compelled to build a house in the ruins. Add to these *contretemps,* that he had frequent notice from the Berlin consul, and from the Pacha, at Smyrna, as well as from the local authorities, that there were brigands in the vicinity, and that if he remained it would be entirely at his own risk, and it will be seen that such investigations require no small amount of courage and resolution.—*The Builder.*

CORNISH PUMPING ENGINES.—The number of pumping engines reported for November, is 20. They have consumed 1,225 tons of coal, and lifted 8.5 million tuns of water 10 fms. high. The average duty of the whole is, therefore, 46,700,000 lbs., lifted 1 ft. high, by the consumption of 112 lbs. of coal. The following engines have exceeded the average duty:

Chivertoon Moor, 70 in.....Millions	54.0
Great Work, Leed's 60 in.....	54.9
North Wheal Crofty, Trevenson's 80 in.....	56.2
Providence Mines, 40 in.....	48.5
South Wheal Frances, Marriott's 75 in.....	54.4
West Wheal Seton, Harvey's 85 in.....	59.2
Wheal Seton, Tilly's 70 in	51.7
Wheal Seton, Tregonning's 70 in.....	68.9

HARDNESS OF METALS.—An instrument for determining the hardness of metals has been invented by a French engineer. It consists of a drill, turned by a machine of a certain and uniform strength. The instrument indicates the number of revolutions made by the drill. From this, compared with the length of the bore-hole produced, the hardness of the metal is estimated. It is said that most rails are tested in France by this instrument.